FEBRUARY 1955

SAE Journal

Published by The Society of Automotive Engineers

is an overwhelming preference

Yes, 35 out of 37 engine manufacturers using

chrome rings specify **Perfect Circle** piston rings!

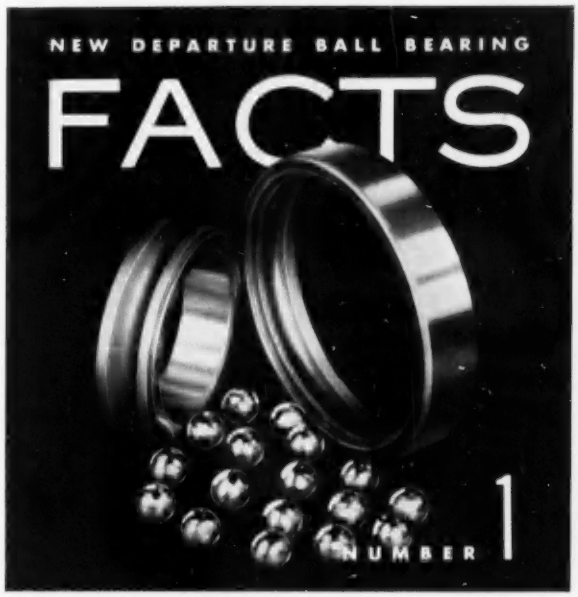
Automotive engineers prefer Perfect Circles because Perfect Circle offers:

1. **Quality Control** 2. **Sound Engineering** 3. **Service** 4. **Experience** 5. **Proved Performance**

Perfect Circle Corporation, Hagerstown, Indiana; The Perfect Circle Co., Ltd., Toronto, Ontario

PRECISION SOLUTION

to combination loads!



Combinations of axial and radial loads on moving parts present a constantly recurring problem to the engineer and designer. And this problem is further multiplied by today's demand for lasting precision with minimum service and adjustment. Naturally, too, every designer strives for a basic simplicity in his product that means manufacturing economy.

A Job For Bearings

The work of holding moving parts in a predetermined position or location must fall on the bearings. How well they maintain the desired accuracy . . . and for how long . . . determines their value.

Because of certain inherent qualities, ball bearings offer outstanding advantages that can be found in no other type of bearing.

Basic Advantages Of The Ball

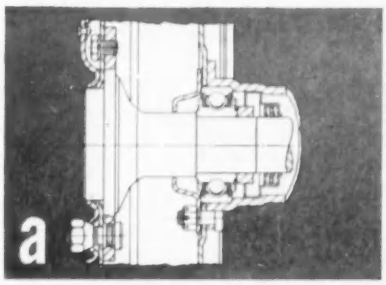
The ball is a unique shape. It rolls naturally in any direction. It has no weakest point. In combination with raceways of proper design, it can resist all loads.

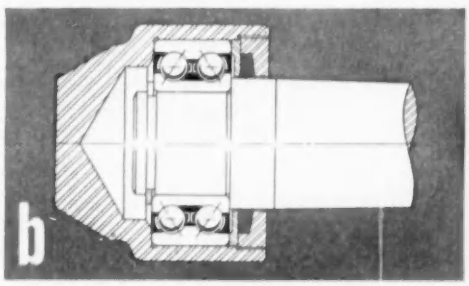
Parts are held rigidly in position and, since wear is virtually nonexistent in properly enclosed ball bearings, no adjustment is required. Regardless of the angle at which load is applied, a uniform and readily calculable resistance is presented, and bearing life may be accurately predicted. Ball bearings thus may be readily selected to match the service expectancy of the machine in which they are used.

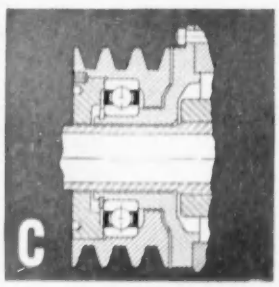
New Flexibility For Machines

Through this ability to resist all loads, machines using ball bearings can be operated in any position and at high or low speeds. One compact ball bearing can often replace an installation of two other bearings of different load-carrying abilities.

New Departure will welcome the opportunity to work with you on any bearing problem. Remember, there is no substitute for experience—and for more than 50 years New Departure has led in bearing design, testing and manufacture.







A. In this automobile rear wheel mounting the axle shaft is located against thrust in both directions by a single New Departure Sealed-for-Life bearing. Adjustments and need for relubrication are eliminated. Here are definite advantages over other types of anti-friction bearings.

B. In applications subject to heavy thrust, such as live centers, double row New Departure *ball* bearings give excellent performance. These bearings may be internally preloaded for maximum resistance to deflection under load. In this example, the center nose is ground after assembly.

C. In applications such as pulleys, New Departure radial, non-loading groove bearings may be used singly for radial, thrust or combined loads according to rated capacities. Thrust and radial capacities are approximately equal.

For complete information send for Booklet BA-5

NEW DEPARTURE
BALL BEARINGS

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McQUAY-NORRIS MFG. CO. • ST. LOUIS 10, MO.

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Hydraulic, pneumatic and other fluid lines can be connected or disconnected quickly, easily and safely with the two-way shut-off couplings made by **The Hansen Manufacturing Company** of Cleveland. When connected the Hansen coupling permits a free flow through it—and a **Precision "O" Ring** makes the vital seal which insures a long life of leak-proof service.

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1954

ONE car manufacturer selected the new piston

1955

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RING LAND PROTECTION

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ST. LOUIS, MISSOURI

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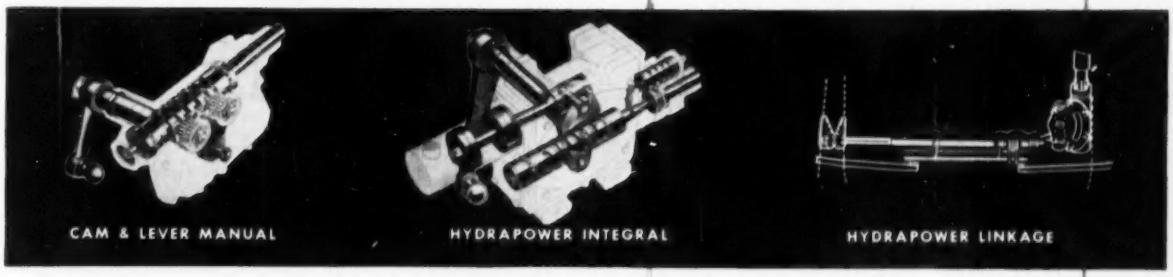

For 49 years Ross has anticipated and met the *ever-changing* and *increasing* needs of the automotive industry for new, finer steering performance, safety and economy.

The experience thus gained—in steering research, engineering, design and manufacture—is dedicated to *one* purpose—to help solve *your* steering problems.

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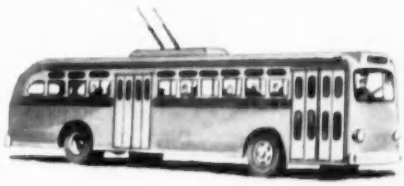
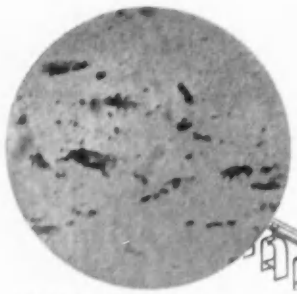
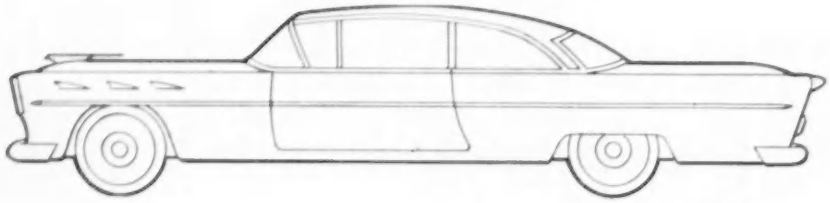
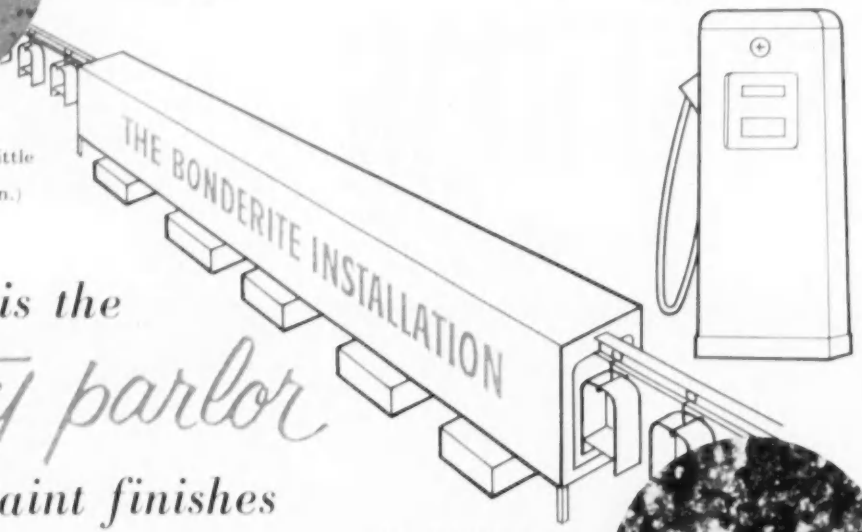
Ross STEERING





BEFORE BONDERITE . . .
Plain metal surfaces are smooth, slippery, offer little for paint to hang on to. (100 times magnification.)





This is the beauty parlor for fine paint finishes

AFTER BONDERITE . . .
Bonderite-treated metal has a fine, nonmetallic phosphate coated surface, takes and holds paint securely. (100 times magnification.)

As the photomicrographs show, a trip through the Bonderite "beauty parlor" changes the surface of metal—changes it to a nonmetallic over all phosphate coating which is integral with the metal itself.

This coating protects and preserves beauty three ways: (1) by anchoring the paint, (2) by resisting rust and corrosion, and (3) by preventing the creep of finish failure if the paint film is scratched or broken.

The leading painted metal products in every classification, from automobiles and appliances to steel windows and x-ray equipment, are treated with Bonderite.

Your metal products, too, should all go through the Bonderite "beauty parlor" before they arrive at the paint booth. It's the economical, effective, *proven* way to assure lasting fine appearance for fine paint finishes.

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you can't have style–
and roominess, too–with

SOFAS-ON-WHEELS!

As long as motorists demand still lower, still sportier-looking cars, your seating problems will continue to mount.

Something must give, under those lower and lower tops of yours – and nothing can be more easily spared than over-bulky upholstering reminiscent of Grandma's parlor but out of place in a modern car.

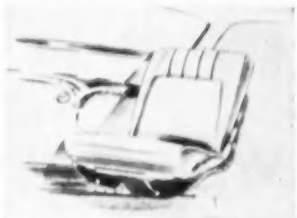
Airfoam Development Engineers are making giant strides in that direction. Working with leading automotive designers, they are shaping entirely NEW seating.

It's seating that will deliver superlative riding comfort–*and without one cubic inch of useless bulk!*

AIRFOAM seat-units can now be molded as a one-piece finished cushion. This will eliminate springs, loose padding and much costly upholstery work. Best of all it adds style and glamour to your smartest models – and will reclaim more usable ROOM, while giving driver and passengers a more comfortable ride.

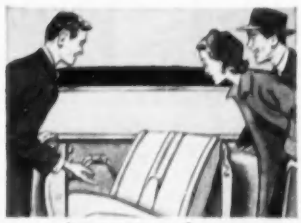
Like to check on the progress already made? Simply contact Goodyear, Automotive Products Dept., Akron 16, Ohio.

AIRFOAM *makes interiors roomier, more luxurious*



Exciting new seating ideas become practical with AIRFOAM

AIRFOAM *gives custom looks at competitive prices*



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THE WORLD'S FINEST, MOST MODERN, CUSHIONING

Airfoam–T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

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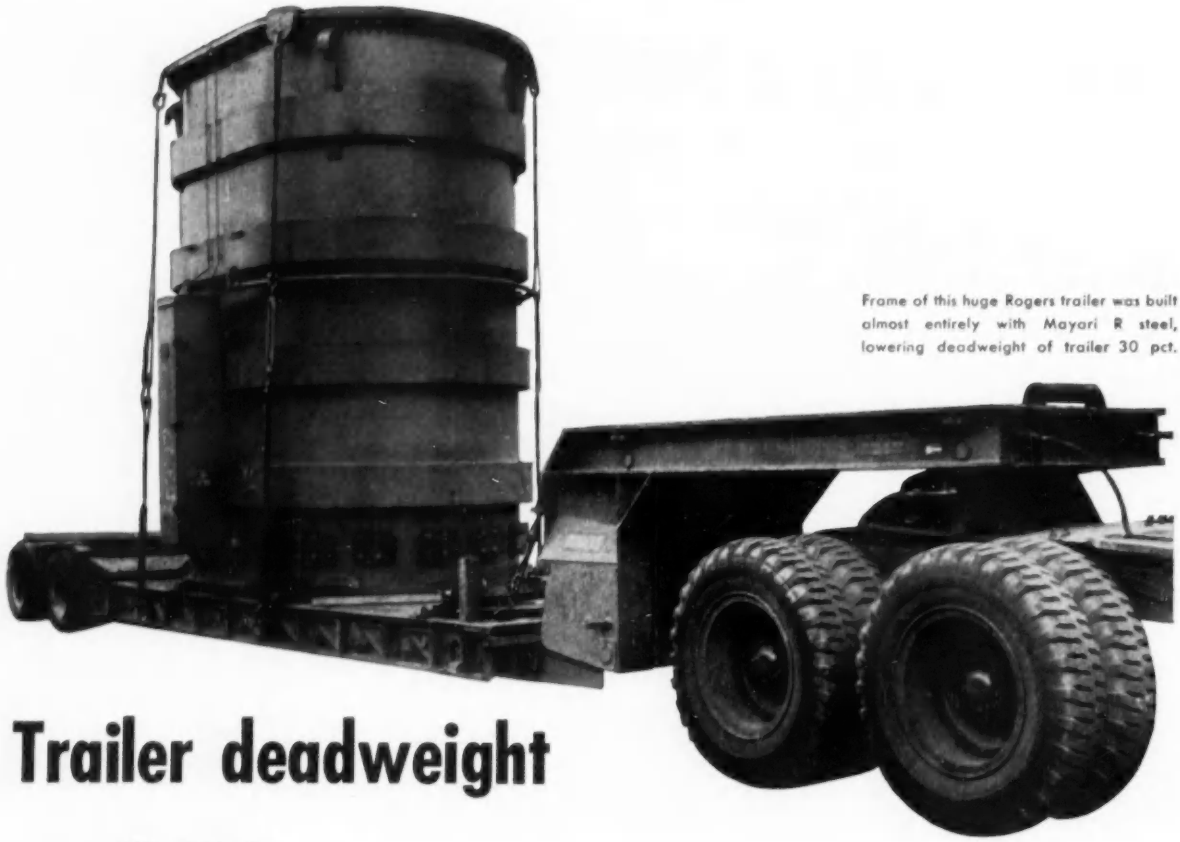

Frame of this huge Rogers trailer was built almost entirely with Mayari R steel, lowering deadweight of trailer 30 pct.

Trailer deadweight cut 30% with Mayari R

Hauling ponderous loads like this is routine work for the heavy-duty trailers built by Rogers Brothers Corporation, Albion, Pa. That calls for a nice balance between strength and weight, to sustain the load while complying with highway weight limitations.

To meet these requirements, Rogers Brothers use Mayari R low-alloy, high-strength steel in all main carrying members. Heavy models, such as the one pictured here, are framed almost entirely with Mayari R, including main beams, splice beams, flat gooseneck beams, cross members, outriggers and reinforcing bars. Because Mayari R has 50 pct greater strength than structural carbon steel, designers can specify it in lighter sections to obtain desired load capacity. In this way, they cut about 30 pct deadweight from the trailer—a substantial poundage on vehicles of this size.

Other vehicle manufacturers are making increased use of Mayari R to lower deadweight in heavy truck bodies, walk-in panels, buses, tankers. Shop men find they can weld, form and work Mayari R without any special equipment or techniques. Owners like the fact that Mayari R holds paint much longer than carbon steel, and resists atmospheric corrosion 5 to 6 times better.

These and other aspects of Mayari R low-alloy, high-strength steel are covered in our new Catalog 353. You can get a copy promptly by writing or calling the nearest Bethlehem sales office.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

Mayari R *makes it lighter... stronger... longer lasting*

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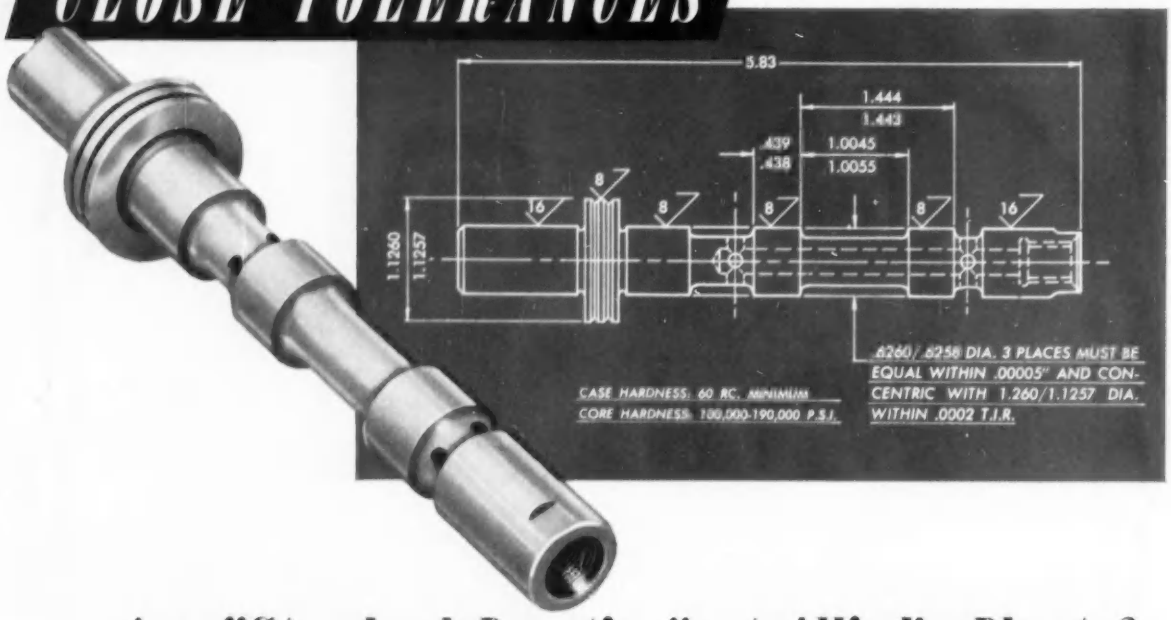

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SPECIAL COLD FORGED PARTS • STANDARD CAP SCREWS • SHEET METAL DIES PRODUCED IN IRON, ALLITE (ZINC ALLOY) AND PLASTIC • R-B INTERCHANGEABLE PUNCHES AND DIES

Here's an aircraft part on which three O.D. surfaces must be equal within .00005", and concentric with the largest outside diameter within .0002". On these *same* diameters a surface finish of 8 microinches is required. Heat-treating must also be to exacting specifications.

Such precision in the production of many types of parts—most required in large volume—is the rule rather than the exception at Allied's Plant 3. That's why Allied has become a preferred supplier in not only the aircraft industry but with other types of manufacturers who demand the best in precision hardened and ground parts.

Allied also offers special facilities for production of parts in experimental or short run quantities. If your present or future needs call for precision parts, it can be definitely to your advantage to secure Allied's quotation. Send us your part prints . . . you'll receive a prompt reply from us.

MORE INFORMATION . . .

on the scope of manufacturing operations at Plant 3 is contained in this new brochure. Write for your copy . . . no obligation, of course.

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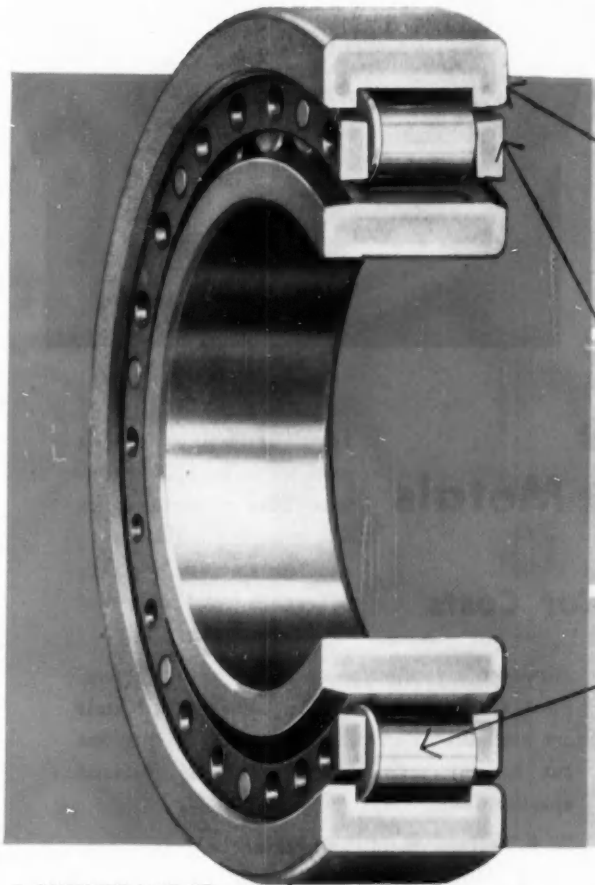
Here's why BOWER straight roller bearings can carry maximum loads—with less maintenance!

The important design features of Bower straight roller bearings shown on this page are just a few of the reasons why these bearings will operate efficiently and economically in your product. Consider these facts, too. Bower straight roller bearings incorporate highest quality materials and workmanship. They have proved themselves capable of standing up day in and day out under maximum loads—with little or no maintenance.

In fact, this is the reason why Bower straight roller bearings are used extensively by leading manufacturers in such fields as automotive, earthmoving, farm equipment and machine tool.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



● ***TWO-LIP RACE INCREASES RIGIDITY.*** These two shoulders, made parallel, are integral with the outer race. This provides a more rigid, durable construction. Rollers are kept in proper alignment at all times.

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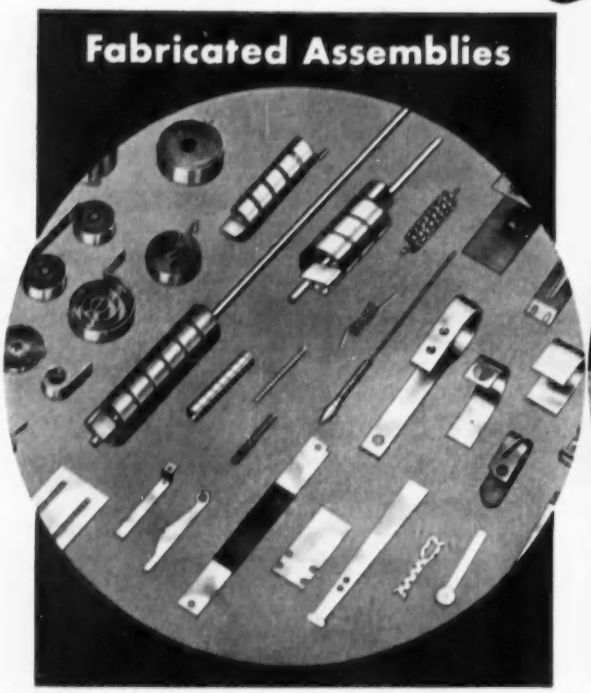

General Plate TRUFLEX® Thermostat Metals

Give Accurate Temperature Response . . . Cut Costs

General Plate *Truflex* Thermostat Metals provide a sure way to get reliable performance and at the same time cut costs of products requiring temperature control, indication or compensation.

Advanced General Plate production methods coupled with the best equipment available insure close tolerances on all properties and dimensions. This maintains positive consistency in thermal, mechanical, and electrical performance. With no variation from lot to lot rejects are eliminated, costly adjustments are minimized.

General Plate *Truflex* fabricated assemblies are engineered and manufactured to your specifications, ready for installation into your products. They eliminate costly fabrication problems . . . needless special equipment . . . experimental work and expensive calibration.

However, if you prefer to make your own assemblies, General Plate *Truflex* Thermostat Metals are available as strip in extra long coils or flat cut lengths manufactured to your material specifications.

Write for information and engineering assistance.

You can profit by using General Plate Composite Metals!

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For the Sake of Argument

Truth Has No Anniversaries . . .

By Norman G. Shidle

Truth, fortunately, has no dates.

Men celebrate from time to time the anniversary of this or that truth in which they believe. And, in the infinite variety of what they celebrate, point to the unity of all that is celebrated.

The unfoldment of truth, which has brought so much progress in the last 50 years, will bring more in the next 50. The reality of the progress will remain proportionate to the degree of the unfoldment in the hearts of men.

Progress in the half-century ahead will continue to be the creation of mind rather than of hand; of stout hearts rather than stern measures.

SAE will contribute its share to this future progress, as in the past. Its contribution continues sure because it is the product of the forward movement of many minds; of the unfoldment of truth in many hearts.

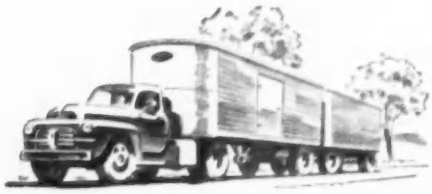
Unfoldment comes to every man—at different rates of speed, in varied forms. Truth unfolding makes engineers of some, artists of others. It makes a thinker of one, a doer of another. In most of us it unfolds as a variety of talents . . . from which we may select those most applicable to our daily tasks.

Truth is the sunlight; man, the window. The light is always shining, even when the window is sooted.

Truth is eternal . . . in its availability to searchers, in its power for good, and in its patient unfoldment to turbulent humanity.

Truth has no anniversaries.

EATON 2-SPEED AXLES keep Trucks on the Job- Reduce Maintenance Costs



By providing a gear ratio best suited for each road and load condition, Eaton 2-Speed Axles permit engines to work in their most efficient and economical speed range, reducing stress and wear on operating truck parts. Truck maintenance is reduced, trucks deliver more on-the-job hours. In addition, because of Eaton's exclusive planetary design, forced feed lubrication, and extra rugged construction, there's less maintenance on the axle itself. When axle repair is required, Eaton's down-to-earth design makes the work quick, easy, and economical. Trucks with Eaton 2-Speed Axles last longer, earn more at lower cost, are worth more on the trade-in.

More than Two Million Eaton Axles in Trucks Today!

EATON AXLE DIVISION
MANUFACTURING COMPANY
CLEVELAND, OHIO

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

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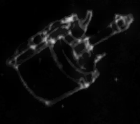

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Specified by more car manufacturers than any other make, Bendix Low Pedal Power Brake makes possible quick, sure stops by merely pivoting the foot from stop-and-go controls. No need to lift the foot and exert leg power to bring the car to a stop. Result—more driving comfort, less fatigue and greater safety!

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*REG. U.S. PAT. OFF.

The term "Bendix Power" not only identifies the industry's outstanding power braking and power steering equipment, but describes the unmatched engineering and manufacturing resources behind these products.

It is well that Bendix Products Division be thought of in this dual capacity, for the outstanding acceptance of Bendix power units stems largely from the fact that industry has learned over the years to look to Bendix for the latest and best in power equipment for cars, trucks and buses.

Bendix Products Division

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The Story of SAE . . .

. . . in its first 50 years is the story of men of good will . . . men of good will searching, growing, and creating together who kindle within each other . . .

UNDERSTANDING in the blending of human values with technical considerations in cooperative attack on engineering problems.

SENSE OF SHARING by passing on to others individually-developed engineering knowledge, skills, and advances.

STIMULATION to self-expression of their individual talents.

INSPIRATION to strive continuously for ever higher technical goals, as individuals and as a professional group.

SATISFACTIONS from the mutual search for new engineering goals with men with common interests, desires, and attitudes.

More than ever before, this picture of men searching, growing, and creating together was in evidence at the launching of SAE's 50th birthday at the Golden Anniversary Annual Meeting in Detroit last month.

1905 S·A·E GOLDEN ANNIVERSARY 1955

The flavor of this largest meeting in the Society's history has been captured by SAE Journal photographers and reporters in the pages of this issue, starting on ..... **p. 106**

Nuggets from Golden Anniversary

Maurice Olley

"There is nothing more dangerous for the driver than somnolent passengers, and even a television set for these fellow travellers might be encouraged!"

Progress in Passenger Cars

see Page 20

"A glorious opportunity is open to engineers for additional standardization of attachment points so that one manufacturer's cultivator will fit another man's tractor."

C. E. Frudden

Sound Tractor and Farm Machinery Future Grown from Varied Past

see Page 40

"Something is required to replace chemical fuels, if extra-terrestrial flight is to be achieved; there are no serious difficulties other than the financial one."

Arthur L. Klein

The Future of Aircraft Engineering

see Page 28

E. F. Gibian

"We're at the beginning of a new epoch in manufacturing which will bring to fruition machine tools that take directions from a punched tape to fabricate complicated parts without using tooling."

Production Engineering: A Forecast

see Page 48

"The trend will be toward bigger trailers and multi-unit trains rather than toward single trucks."

C. A. Lindblom

Future Trucks and Buses

see Page 33

"Some of the most common of our metals are beginning to be prepared for services formerly performed only by the relatively scarce materials such as nickel, chromium, cobalt, and molybdenum."

G. C. Riegel

What's Ahead in Engineering Materials

see Page 54

Articles in this issue:

T. A. Boyd

"Some of the more urgent problems include that of dredging out a more complete and useful understanding of combustion in the gasoline engine, the diesel engine, and the gas turbine."

SAE In Fuels and Lubricants—Yesterday, Today, and Tomorrow

see Page 63

O. A. Brouer

"And with more efficient brakes, transmission and drive components, and better roads, trucks will operate safely at 100 mph."

Future Trends in Automotive Transportation and Maintenance

see Page 74

C. G. A. Rosen

"Future developments in diesel engines will tend toward the combination of high supercharge with a proper air excess of approximately 100% or so in order to obtain insensitivity to mixing difficulties."

Diesel Engines . . . What Lies Ahead

see Page 82

"I will predict the elimination of aircraft powerplants as we now envision them by the year 2005."

P. B. Taylor

The First 100 Years of Aircraft Powerplants

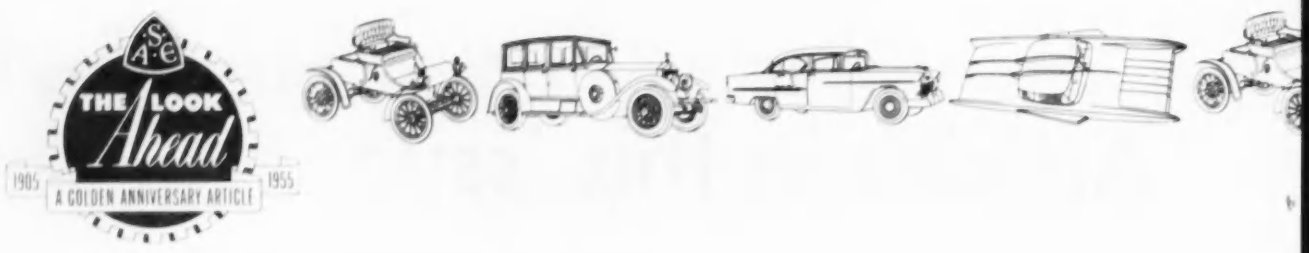
see Page 89

". . . within 50 years almost anything material that we can discern today as needing to be done, can and will be accomplished."

William Littlewood

From Gold to Diamond in Air Transport Engineering

see Page 97



Progress in

TECHNOLOGICAL progress since the war era, rapid developments in suburban living, the new highways, and an economy ever more dependent on road transport . . . all these factors and many more seem to ensure that the next 50 years of the SAE will see intense activity in passenger car progress.

In the last 25 years, the chassis engineer has gained a wider appreciation of the car as a whole, while at the same time the stylists, and in fact everyone concerned, came to share the burden of the engineer.

There can be no question that car design will engage the best efforts of the entire engineering staff, design, production, experimental, and service, as well as the styling and coachwork engineers. Aerodynamic engineers may also play an increasing part especially in the field of directional stability. Already in 20 years, besides reducing the frontal area, we have halved the coefficient of wind resistance, and it appears possible to halve it again. At a given speed we are already spending far less money just pushing the air around than we were 25 years ago.

The American car is necessarily designed for existing American highways. The American car of 1910 was designed for the then existing lack of roads, and the car of 1960 will equally have to be made to operate at best advantage on the highways of 1960. However American car design, modified by the necessary changes in linear scale, is now almost international in range, and only minor variations are required to adapt it even to the least sophisticated parts of the world.

From what has been said above, we can expect the steady forward and downward progress of the passenger space to continue. The downward movement eventually coming to the limit set by the ground clearance, and the forward movement to the limit set by the front wheels, provided that we can clear up the resulting congestion under the hood and toe board.

We are left with the shaft tunnel. But any chassis engineer can think of at least half a dozen ways for getting rid of this obstruction. And, to quote another European engineer, "this subject is too close to our hearts for public discussion."

There remains the possibility of pushing the engine clear out through the front of the car, and bringing it in again at the rear. As Harley Earl has said in his recent article, this won't be done until problems like weight distribution are solved, and only then if there is a compelling advantage to the owner, an advantage incidentally which is not so far apparent.

More probable is a continuation of present trends, the passengers claiming more and more of the platform area which rightly belongs to them, and the mechanism adapting itself to conditions.

What the trend has been as regards the engine can be seen from the following charts.

Despite the occasional monstrous engines of the twenties and a peculiar tendency for large engines in the depression years, the average size of American passenger car engines has remained surprisingly close to 250 cu in. for the last 30 years. (See Fig. 1.) At the same time the horsepower per cubic inch has increased from 0.23 to 0.56, and the trend is now rapidly upward. (See Fig. 2.) Improved fuels have allowed an increase in compression ratio since 1925 from 4.4 to 7.3 (rising to 8.5), as shown in Fig. 3, and an increase in average horsepower from 60 to 135 (which also is still rising). See Fig. 4.

As we all know the fuel and oil engineers have contributed as greatly to this result, as shown in Fig. 5, as have the tire engineers to the overall increase in speed, safety, and stability.

This improvement in engine performance is all of a piece with the "horsepower race" which began around 1905. The excess horsepower available is a necessity for safe overtaking. Acceleration of a vehicle represents a certain investment in kinetic energy; and to accomplish it in a given time there is no substitute for horsepower.

There remains the possibility of even further reductions in engine length.

A mere reduction in displacement without changing the arrangement of cylinders will not achieve

Passenger Cars

by Maurice Olley

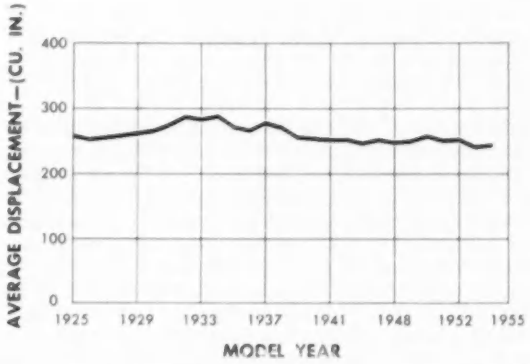


Fig. 1—Trend of displacement in American passenger cars since 1925

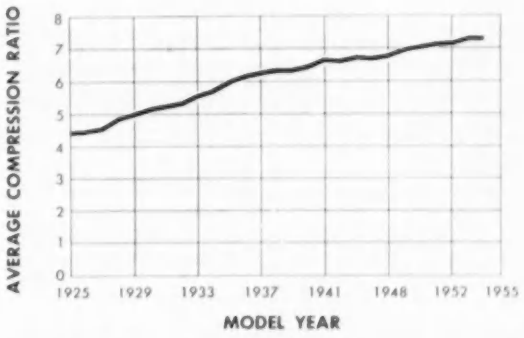


Fig. 3—Trend of compression ratios of American passenger cars since 1925

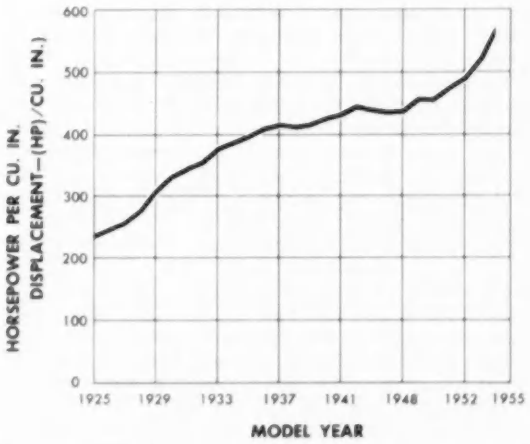


Fig. 2—Trend of horsepower per cubic inch of displacement of American passenger cars since 1925

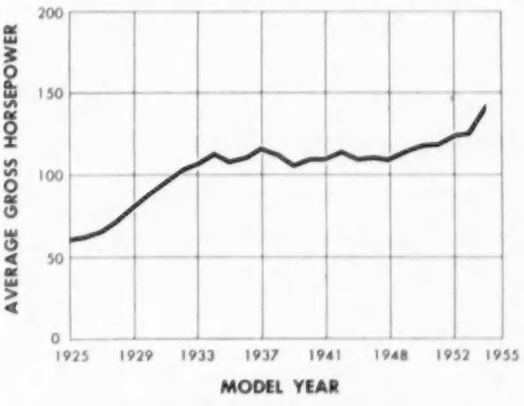


Fig. 4—Trend of engine gross horsepower of American passenger cars since 1925

SAE Golden Anniversary Author

Maurice Olley

Maurice Olley is director of research and development of Chevrolet Motor Division, General Motors Corp. He has been associated with various divisions of GMC since 1930.

He was born in 1889 in Scarboro, England and became a citizen of the United States in 1925. He attended the Birmingham Technical School and the University of Manchester in England.

He started his industrial career in England with H. W. Ward and Co., Ltd. of Birmingham as a premium apprentice. In 1912 he joined Rolls-Royce, Ltd. as a draftsman and served with them in England until 1917. He then came to the United States and worked with Rolls-Royce of America, Inc. In 1930 Olley joined the Cadillac Division of GMC. Olley did much of Cadillac's development work on the individual front suspension. He returned to England in 1937 to serve for two years with Vauxhall Motors, Ltd., a General Motors subsidiary.

For three years during World War II, Olley worked for the British Ministry of Supply on tank problems. After the war he returned to Vauxhall. In 1953 he came back to the United States to become director of research and development for Chevrolet.

Olley is a member of the SAE Riding Comfort Research Committee, the Spring Committee, and the Passenger Car Activity Committee.

appreciable results. The Europeans have tried V-sixes, V-fours, flat fours, flat 2-cyl engines, and 2-cycle engines with 2 and 3 vertical cylinders. It seems highly improbable that Amreicans will be satisfied with fewer than six cylinders; but within this limitation there is still some room for shortening and lightening the powerplant.

And with the engine pushed far enough forward, there may be room for the transmission to change its shape so as to clear the toe board and floor.

It may be objected that the gas turbine will come along to change radically the whole shape of our vehicles, particularly in view of the fact that disposal of the exhaust at present demands mounting this powerplant in the rear. One need only imagine what a traffic jam of gas turbine cars would be like in hot weather, to hesitate in predicting any rapid swing in this direction. A drastic change in the whole nature of gas turbines would be required before this becomes possible. And such a change would imply a small, neat power package, such as might be mounted in the present forward location.

Improving performances will demand better brakes and this improvement in various forms is certainly to be looked for from now on.

With regard to the weight of American cars no drastic change in average shipping weight has occurred since about 1935, prior to which there had been a rapid increase from 3000 lb in 1927 to 3450 in 1933, and an even more sudden reduction in 1935 to about 3200 lb, ever since which time the weight has held fairly close to 3250 lb. (See Fig. 6.)

The struggle to give the public the luxury items which become necessities overnight and still keep the weight down, is familiar to every engineer, and accounts for the fluctuations on the chart. But we are more weight conscious every year, we are gaining experience in raising safe stress levels, and are continually finding simpler and lighter ways of accomplishing results. So it may be safe to assume that this average weight of 3250 lb will not be much exceeded in the next 10 years, and that it may be reduced.

There seems no immediate prospect for a general acceptance of radically smaller cars in spite of, and perhaps because of, the increasing number of small imported cars in our midst. Although these will fit in smaller parking spaces, the actual parking of the closed models is not as easy as that of an American car with power steering, because of restricted vision and less physical freedom for the driver.

The weaving in and out of heavy traffic which is supposed to be one of their advantages is a practice frowned on by the police. And on the open highways, although these cars are credited with adequate or even excessive speed, they are not so driven by their owners, and actually do not in general keep up with the traffic flow, and therefore form an obstruction.

There is however a new factor which may demand certain changes in our cars.

The new expressways permit, and, by universal practice, actually require, the maintenance of a

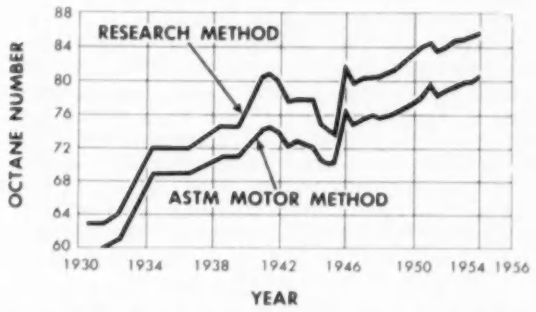


Fig. 5—Trend in antiknock quality of regular gasolines sold in the United States

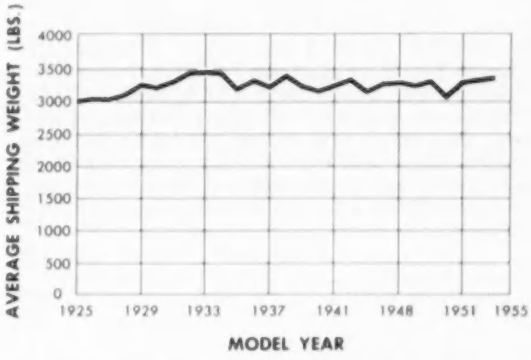


Fig. 6—Trend of shipping weight of American passenger cars since 1925

uniform speed of 60 or 70 mph for many hours on end. The universal character of such roads is that there is no opposing traffic, no cause for sudden stops, and no sharp turns.

One requirement is certainly a further development of "cruising gears" for effortless strolling at these speeds, combined with a smoothly operating step-down to passing gears for rapid overtaking.

Another requirement, along the same lines, is quieter interiors to reduce fatigue. This includes the reduction of wind noise, either by suitable modification of airflow past the open windows, or by abandoning open windows entirely, and using flush glass and air-conditioning. Other noises can be reduced also, including fan noise, intake and exhaust, and the complex assortment classed under "road noise."

Again, could we not free the driver's feet by reinventing the old hand throttle operating through a governor which would maintain a given set speed up-hill and down, with the single addition that it should be instantly cancellable by the accelerator?

On such roads the only danger is boredom. In fact, it is doubtful whether such moderate top speed limits are actually as safe as we think they are, for this very reason.

Safety Demands "Fidget Room"

To avoid boredom we need room to fidget. What this implies in the way of seat widths, flat floors and foot room I do not know, but I am sure the last thing in the world we want is bucket seats and safety belts, or anything conducing to a sense of confinement.

It seems perfectly possible that a radio may be considered an essential safety device, and a few exciting "westerns" may reduce the accident toll on hot afternoons.

Intelligent conversation conducted in a normal tone of voice can certainly help, and quieter interiors would make this easier.

There is nothing more dangerous for the driver than somnolent passengers, and even a television set for these fellow travellers might be encouraged!

This business of sitting in a state of suspended animation waiting for one's destination to roll around, is quite new in automobile travel. It raises two problems—(1) to maintain the alertness of the driver on the expressways, and (2) to help him to adapt himself rapidly to the changed conditions when he emerges from them into the 19th century texture of our cities.

Our forecast of what forces will shape the car of the future, and how, stems from an extrapolation of the passenger car's metamorphosis from its early days to the present. So let's take a look at the first three stages of car development.

STAGE 1:

Courageous Pioneering

Pioneer American and European cars developed differently. The American, designed for a country almost without roads, had the ground clearance and the size and weight of true pioneer vehicles.

The European cars had a magnificent 18th century road system ready and waiting, and developed from two different origins with a sharp class distinction between them, one group coming upward from the bicycle, and the other meeting the demands of the carriage trade. These two classes have scarcely merged in Europe today.

Regardless of class, all the early gasoline cars were ugly and unreliable and a source of mixed pride and terror to their owners. The starting handle was

a visible threat to life and limb. Eventual breakdown was inevitable, the only questions being where and when. Only a first rate mechanic with the requisite touch of insanity and a total disregard of comfort and cleanliness, could run the things.

The coachwork, when there was any, was fairly good. The coachbuilders had had centuries of experience. The chassis engineers had had none and were groping their way. No wonder then that their progress, if not really fast, was at least dramatic, since everything was crying for improvement.

STAGE 2:

The Machine Flexes Its Muscles

The second stage marks the increasing dominance of the chassis engineer. The mechanism, being unreliable, must be accessible. The engine emerged in front, housed in a collapsible metal box which could be dismantled in a moment.

The dash became a mass of trembler coils, drip-feed lubricators, and an array of scientific instruments for the initiated. The chassis with its adjustments, its many grease cups, its rods and levers, was brought out into the open.

And, as early as 1905, the horsepower race was on. The need for overtaking, especially on unmarked roads with blind corners, called for excess power as a matter of safety. The 3 hp of 1900 became the 30 hp of 1910, and the 50 hp of 1920. Engine speeds were on the increase—they had come up from 500 rpm to 2000 rpm. But fuels available held the compression down to 4 or 4½, so that especially on the larger cars, engine size grew enormously in spite of taxation schedules based on power ratings.

Hence the growth of enormously long and high hoods and a general exaggeration of the chassis. The complete car became a revelation of family discord between two incompatible temperaments, the rigid severity of the chassis, and a certain hesitating waywardness in the body lines. The chassis dominated, representing 60 or 70% of the total cost and effort. The coachbuilder practiced his art on sufference under warning not to obstruct the 50 or 60 chassis components which required attention every 500 or 1000 miles. In those days, one of the hallmarks of a fine car was the provision of an elaborate display panel for the equally elaborate tool kit, which turned every self-respecting automobile into a service station on wheels.

The transmission, separate from the engine, and still beneath the floor, (which however must be instantly removable for access to it), was still unblest by any assistance for gear shifting by the unskilled driver. The chassis engineer felt that any person unskilled in the mysteries of double-clutching had better stay home.

In retrospect, the most striking thing about this era is the elaborate means adopted to accomplish simple ends, the constant use of steam hammers to crack nuts. Especially the minor parts, the controls, the mechanical and electrical details, the adjustments, and so forth, are almost incredible until one recalls that the plastics industry was just starting, the uses of bonded rubber were scarcely known, and there were no useful synthetic rubbers.

Modern oil seals were also unknown. The chassis components dripped oil and grease everywhere, but all chassis wore a metal apron under their mechanism as a general repository for nuts and bolts, grease, and road dirt. With the coming of the non-removable body floor towards the end of this era, this underpan diminished and disappeared, the car hoist came into existence for servicing, and we had, all unknowing, paved the way for the third stage.

The climax of this second stage came in the twenties. The platform area between the four wheels, which should evidently have belonged to the passengers, was now occupied nearly 50% by the mechanism of the car. The rear passengers, who, in general, had paid for the car, were thrust up into the air by the ample kick-up, and rode back of the axle like an overhung load on a truck.

An article of faith of the day was that the radiator, which was the distinguishing feature giving character to the vehicle, must never advance beyond the centerline of the front wheels. This left an unsightly box canyon between the wheels, originally used for the starting handle which no longer existed.

Towards the end of this era, the five-passenger sedan began to displace the old touring car as the accepted standard vehicle. And in the sedans the family quarrel between chassis and body really came to a head. In appearance the entire car leaned backwards, as though reluctant ever to go anywhere. Unsightly spare wheels on either side of the hood broke the line of the car and shook monstrously and audibly despite massive retaining brackets. Baggage had to be carried in a box hooked to a rack on the rear. The box had no relationship with the lines of the car, was far from weatherproof, and overhung the rear bumper, frequently with disastrous results. With the box fully loaded, steering of the car was purely acrobatic.

In retrospect, I think we must admit that appearance-wise these cars had nothing.

However, it is easy to criticize, but much more useful to appreciate all the chassis men had accomplished in 25 years. The greatest achievement, which from the viewpoint of 1905 would have appeared completely impossible, was that the four cycle "explosion" engine had been developed into one of the smoothest and most silent prime movers in the world.

At the same time the whole mechanism of the car, which at the beginning barely ran at all and never ran safely or reliably, had now been changed into a completely reliable vehicle. It ran safely, steered properly at the speed of a railroad train, stopped when and where required, and could be serviced by mechanisms developed for the purpose, chiefly from below, without pulling the body apart.

With the cooperation of the coachbuilders, the rubber industry and an increasing host of suppliers, the chassis engineers had suppressed not only the engine noises, but also the alarming parasitic noises which had shown up in the earliest closed cars.

Above all they were no longer stumbling amateurs. After 25 years they really understood their jobs as

few groups of engineers had ever attempted to do before. They had watched and taken pictures of every bit of the vehicle in motion on the road or on the test stand. They had lain under the engines and watched the pistons moving up and down in cylinders which were far from round. They had sat on the front bumpers and watched the wheels shimmy. They had stood on the rear axles and felt them tramp.

As a result, they had produced a dependable mechanism which had come to dominate personal transportation in North America, and was close to doing so in the rest of the world.

Now the time had arrived to close up their box of tricks and move it out of sight.

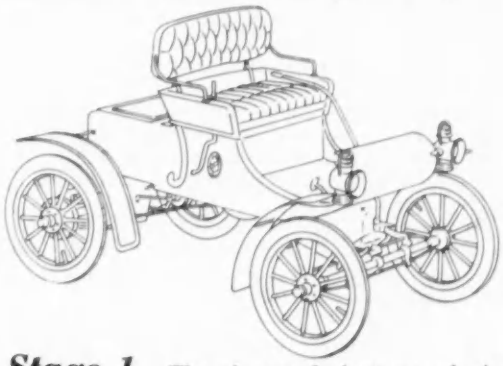
STAGE 3:

The Stylist Rules The Automotive Roost

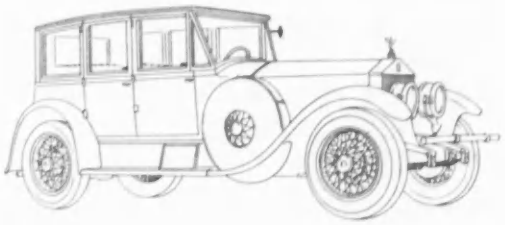
This period marks the coming of the stylists. From the early thirties, or even the late twenties, the voice of these gentlemen had been heard in the land, proclaiming the shortcomings of our cars, and occasionally showing us samples of advanced designs (which we thought very peculiar) to illustrate their ideas.

The reign of the stylists has been marked by a steady pressure, like a glacier flow, maintained year

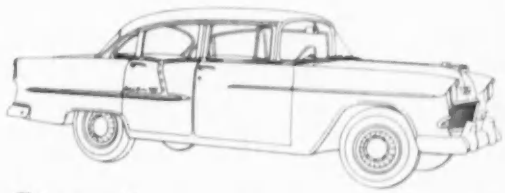
The Four Stages of Passenger Car Design



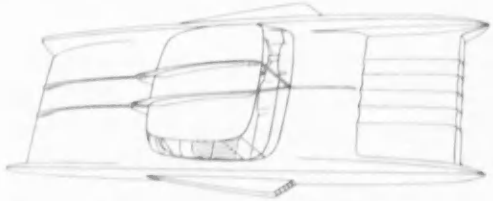
Stage 1. The pioneer designs were logical, but not practical. They were essentially carriages with the platform space devoted to passengers, and the mechanism tucked decently out of sight. This was unpractical only because the mechanism was unreliable, and the car spent most of its life dismantled to get at its innards.



Stage 2. The second stage represented the reign of the chassis engineers. It was practical, but illogical. The car developed into a road locomotive with the passengers merely catching a ride on its rear end. When closed cars came along, the appearance was so unsightly and reluctant-looking as to lead to . . .



Stage 3. . . . the age of the stylists. This is essentially a return to the logical. The platform area is reclaimed by the passengers. The car is designed to move through the air and look as though it wanted to do so. The mechanism is again tucked out of sight. This is now practical because the mechanism is reliable. The impact of this modern design is international in scope.



Stage 4. The coming fourth stage may be more dramatic in character or less so. The pressures which have developed in Stage 3, and the great variety of means for meeting them, may make for radical changes. But the fourth stage will be less the work of any one dominant group. It must be a joint effort of a large number of groups, and it will have to be handled tactfully and in slow stages.

In general we can be sure that the appearance factor will continue to lead, and the mechanism to adjust itself to the shape of the vehicle.

after year, in the directions necessary to mold our passenger cars into a harmonious unit. Their success is marked by the fact that their designs are now the accepted standards not only in the U.S.A., but all over the car-making world. In fact some foreign manufacturers have gone beyond us in carrying out the style trends inaugurated in the thirties.

As a result of the styling movement, our self-complacency of the twenties has given way to a state of mind which is certainly not one of senility and indifference.

It appears to the writer that the chief work of the stylists has been to press the pasenger space forward until it occupies the platform area of the car. In retrospect it seems a simple thing to do, but only those who have followed the last 25 years of the industry can appreciate the effort required.

In 25 years the passenger space has moved a couple of feet closer to the front wheels and has another 6 in. or so to go before the dash encroaches on the front wheels.

Once the rear passengers were clear of the kick-up, the whole pasenger space could come down, and it, and the roof with it, have been coming down at the rate of almost half an inch per year ever since 1927. (See Fig. 7.)

The work of the stylists most noticeable to the public however was the immediate disappearance of the chassis from human sight. At the time this made everyone catch his breath. What was happening to our doctrine of accessibility? In Europe generally and in some American cars, the chassis has actually ceased to exist as a separate entity.

Wheel diameters, which during the twenties had already shrunk from 25 to 20 in., were reduced successively to 18 in., 17 in., 16 in., 15 in., and now show a tendency to discard another couple of inches.

Tire diameters have grown almost in inverse proportion.

Independent suspension came along just in time to permit the engine to move out of the way of the advancing dash, and hang between the front wheels. This moved the radiator forward and filled in the box canyon.

It permitted a front overhang which in side view could balance the appearance of the rear.

For the first time, a passenger car began to look integrated, as though it were one thing, and not several things unsuccessfully put together.

In this process the old stone guard over the radiator core, after going through some peculiar mutations, developed into our present air intakes, much better placed for cooling purposes and freedom from mud. The Europeans who, willingly or not, are following the same trend, criticize our excessive use of chrome in these parts. They forget that chrome plate is easier than color matching, and that on our long straight roads it is highly necessary to know whether a distant car is coming or going.

By making the body wider than the wheel treads, the stylists got rid of the running boards without exposing the sides of the body to the gravel flung by the front wheels.

It is a pity that in the process they thickened the doors. Even without this handicap, the cars are so difficult to enter and leave in a parking lot that one might suggest developing the trunk lid into an emergency exit!

In the classic age of the twenties it was assumed that, since most humans are wider at the shoulders than at the buttocks, the sides of our cars should slope outwards towards the top.

The outward sloping side glass, combined with upright windshields, produced such an amazing

"Senility and Indifference"?

THE 50 years of the SAE correspond closely to the 50 years in which the automobile industry has grown from a peculiar idea to a dominant industry—an industry which has already produced several stalwart offspring, and bids fair to produce more.

There exists, not only in this country, an impression that the early years of the automobile industry were progressive, but that we have now reached a stage described by a modern French engineer as one of "senility and indifference."

He believes that the Americans have entered this stage by deliberate intent, and the French by economic necessity. He thinks the Germans still show signs of life, but that the cars of year 2000 will generally resemble those of today.

The writer's memories of the industry go back much further than those of the French engineer, in fact about as far as the SAE.

I am sure that the true rate of progress is still an ascending curve.

kaleidoscope of reflections that driving through a city on a rainy night was almost a matter of guesswork. Hence the need for a large assortment of window blinds.

The stylists produced cars with "tumble home" and our reflection troubles vanished! We also gained the "fidgetting space" on the seats and floor so necessary for long runs on modern roads.

The forward march of the passenger space left behind it an empty box, into which the spare wheel disappeared, and which at the same time meets the need of suburban living by making every car into an adequate delivery van.

Separate fenders have gone. Only the name survives. The lamps have disappeared into them.

The hood survives also only in name, and as a lid, matching the trunk lid.

The chassis parts, fallen from their high estate, have been shockingly pushed around. The magnificent, lordly engines of the twenties have given way to more compact designs, which work far harder for their living.

These have been crowded forward almost as far as they will go. But the Europeans have managed to move them farther, sometimes by shifting the steering linkage forward of the wheels, sometimes by leaving the steering gear behind and shifting the entire engine forward of the wheels.

In and around this already crowded engine there has been forming a parasitic jungle of air cleaners, power steering, power brakes, air conditioning, window washers, larger generators. And the battery has come forward too to live with the engine and enjoy an accessible location for the first time in its life.

The engine however, which used to be so accessible, is now barely visible.

And the peculiar thing is that in spite of these assaults on accessibility, all these components seem to do very well! And even the air which comes through the radiator seems to find its way in and out again, although our louvers in the hood sides disappeared years ago!

(But, incidentally, the cost in horsepower of pushing the air through this crowded auction room needs further examination.)

The glacier flow of styling developed its greatest pressures in and around the dash and toe board. Flywheels became much smaller than we had believed possible, chiefly for the sake of clearances, but with incidental advantages to smoothness and acceleration.

The transmission now clung to the rear of the engine and became reduced to a quarter of its former size despite the added synchronizers. Its shift lever departed up the steering column and operated by remote controls of a nature such as the chassis engineers in their heyday would never have tolerated.

The increased size of automatic transmissions was hard to digest, but given time these will certainly be made to conform to the general scheme of things.

The hand brake lever became a pull knob, or even a foot pedal! All our treasured little hand controls on the steering wheel had long ago been swept away and replaced by a medallion. And the instrument panel with its collection of scientific instruments had become as easy to read as a popular novel.

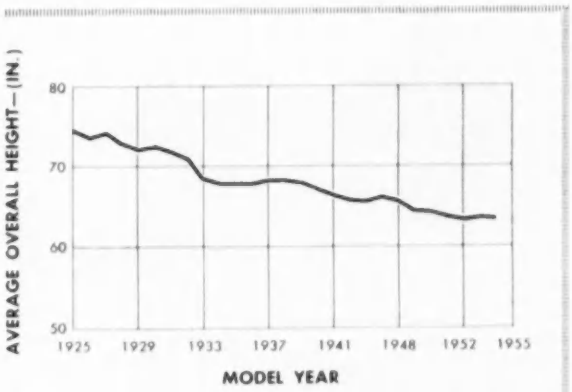


Fig. 7—Trend of average overall height (unloaded) of American passenger cars since 1925

The stylists' conception of a passenger car had arrived!

All this had not been accomplished without setting up some problems.

1. Shifting everything forward on the chassis had reduced the load on the rear tires. Whereas from earliest days these had carried about 55% of the total weight, they now carried only 45%. In terms of center of gravity, this only meant that this center had moved forward about a foot. But, taking into consideration the lowering of the center at the same time, it meant that whereas on a dry road the early cars had about 65% of the total weight available for traction, the modern cars had only 52%. We know from experience that we are feeling this effect, particularly in winter driving.

2. The corresponding increase in weight on the front tires has been blamed for the demand for power steering. But this is scarcely fair. The writer recalls many cars of the twenties which could certainly have used power steering.

3. This new weight distribution has certainly helped the handling stability of our cars in no uncertain fashion. In other words, if by the use of aluminum engines, for example, we should bring our weight distribution back to 50-50, we might have to tackle a high-speed handling problem, especially in high winds.

4. The smaller wheels, large tires, and greater enclosure of the wheels, together with the use of disc wheels, has contributed to a brake problem. We should have run into this anyway, because of the greatly increased car performance; but the wheel and tire conditions certainly do not help.

Not only this, but our weight distribution is now such that at maximum retardation the front tires transmit 70% of the braking force and the rears only 30%

The only thing to be said is that we are finding our way out of this problem, just as we have had to do with the other problems.

The Future of Aircraft

POWERED flight will be one hundred and one years old on the one hundredth anniversary of the SAE. Industries of this age are noted for their stodginess and lack of imagination. Let us hope that our industry will maintain its rate of progress and its freshness of approach.

We hope that the present crop of juvenile imbeciles will not undo our work in building our industry to its present size and usefulness. We often are tempted to take the classical attitude that the new generation cannot amount to anything, forgetting that our generation was one of the most harebrained that ever came along. We actually believed that flying machines would work and be useful. We can therefore hope that with the aid of the psychologists and "human engineers" the new generation of aircraft engineers will make our future vehicles safer, more efficient and useful, and may by means of some as yet unknown powerplants enable us to escape into space.

We in this Aircraft Activity are in all our efforts constrained by the requirements and needs of our customers, so well exemplified by William Littlewood (see page 97), and the output and opinions of the producers of powerplants so ably represented by Philip Taylor (see page 89). We are continually in the position of a chef who is asked to prepare filet mignon from round steak for a customer who can only pay for a hamburger.

Fortunately for us, our fairy godmother, namely, the armed forces, has waved her magic wand and provided us with enough resources to make the above mentioned miracle occur.

Whether the international tensions that presently exist will continue for the next 50 years or whether a relaxed peaceful civilization or a war will replace the present turmoil is anyone's guess. I could, therefore, take the simple (and perhaps too simple-minded) course that the present international and internal conditions will continue. I hope that our industry and the communication industry will continue to do as they have so far done in making world wide access and knowledge available to everyone everywhere.

AIRCRAFT DESIGN PROBLEMS

Our principal achievement, not without its disadvantages, is to provide cheap and rapid transportation for the world. We have now made it possible to get anywhere in our country in one day. Surely in 50 years the whole world will be reachable in the same time. This implies an average speed of at least 1000 mph, which will be attained long before 50 years elapse. To be practical commercially such speeds must be economical.

The threshold of the supersonic era is on us and as the knowledge of the phenomena that exist at these speeds continues to accumulate there is an indication that supersonic flight will be in some ways easier than subsonic. High speeds imply high altitudes, and the studies that have been made indicate that altitudes up to nearly 100,000 ft present few unusual problems. Whether we stay with winged vehicles, or go to rockets; and whether we use heat engines, nuclear engines, or some new and unknown powerplant; the key problem will still be as now that of landing and take-off.

With airplanes the power needed for the desired (and economical) high speeds will automatically give a satisfactory take-off. In the case of nuclear powerplants, the landing problem becomes acute as the nuclear airplane is as heavy at landing as it is at take-off. Therefore the entire airframe and, in fact the entire proportions of the airplane, will be determined by the landing case. Nuclear aircraft will therefore have large and comparatively lightly loaded wings and will have their best performance at comparatively high altitudes.

At the present time the major problems with supersonic aircraft are low speed and landing con-

Engineering

by Arthur L. Klein

trol. Maneuverable supersonic missiles of either the rocket type or the airplane type are not too difficult to design; but with them every landing is a crash. We have been able to achieve a good deal of competency in supersonic design and are at last getting to have some feeling and intuition about this region.

Up to now we have had to proceed either by inventorism, or by the elaborate procedure of calculation and testing to get a satisfactory vehicle. Though difficulties have occurred, they have been superable and we are now at the point where supersonic design is becoming a matter of engineering judgment. The striking thing has been the small number of drawings that are made and the large number of calculations and discussions that are needed. Perhaps this is the way to the future.

Using true rockets (without wings and having thrust larger than their weight) the way to the future is less clear. The low speed control of these vehicles is difficult indeed and has only been solved by the science fiction writers. The true rocket, to be commercially useful, must achieve a landing reliability equal to that of other aircraft. If this is done by the use of reversed thrust, we must also answer the problem of powerless landing.

As far as extra-terrestrial travel is concerned the vehicle designer is completely at the mercy of the powerplant industry. Financing for such an endeavor must be provided non-commercially as the only immediate uses are military and scientific.

The vehicle, except for the landing problem mentioned above, is fairly straightforward, since there are only two other important problems. One of these, the auxiliary power problem, is apparently going to be solved by either the solar energy converter, some of which were displayed lately by some highly reputable organizations; or by means of the direct partial conversion of the energy of radioactivity into electricity. The atmospheric re-entry problem seems to be of an engineering type and needs a great deal of effort but its difficulties are not fundamental.

To reiterate, something is required to replace chemical fuels if extra-terrestrial flight is to be

SAE Golden Anniversary Author

Arthur L. Klein

Arthur L. Klein is a professor of aeronautics at California Institute of Technology and a consultant to the Douglas Aircraft Co., Inc. He has been on Cal Tech's faculty since 1921 and received his Ph.D. there in 1925.

In 1927 Klein joined the C. I. T. aeronautics department and supervised the design of the Galcit Wind Tunnel and apparatus associated with it. He became a member of the design group of the Southern California Cooperative Wind Tunnel in 1941 and has continued in design work for this facility, supervising in particular the design of instrumentation, model handling fixtures, and data-recording equipment.

He has been serving as a general consultant to Douglas Aircraft Co. since 1931. His work has ranged from manufacturing methods to design of airframes and aircraft electrical systems and even to calculating machinery.

From 1943 to 1951 he acted as consulting engineer with Phaostraon Co. in South Pasadena, and ever since 1927 he has been president of the Klein-Norton Co. of Los Angeles.

Klein was SAE vice-president representing the Aircraft Activity in 1948. He has also held active membership in such organizations as the American Society for Metals, the American Association for the Advancement of Science, the American Geographic Society, the American Seismological Society, and the American Optical Society. He is a fellow of the Institute of the Aeronautical Sciences and the American Physical Society.

ON SUPERSONICS . . .

"We are now at the point where supersonic design is becoming a matter of engineering judgment. The striking thing has been the small number of drawings that are made and the large number of calculations that are needed."

achieved; there are no other serious difficulties other than the financial one.

In the next 50 years the helicopter will come into its own. I have never been a believer in aircraft for everyone and am still less a believer in helicopters as a personal vehicle. If our colleagues in the other Activities of the SAE cannot solve the automobile accident problem, we in this Activity have no chance of solving the problem of safe personal aircraft. With helicopters, the problem is even more aggravated as mere contact with another helicopter can be fatal. These infuriated windmills will destroy each other like creatures in a nightmare. Their present difficulties will be overcome when aircraft designers determine how to design high speed precision machinery.

The convenience of the helicopter is so outstanding that its full utilization waits only on improvements in its reliability and safety with a consequent

ON SPACE TRAVEL . . .

"Something is required to replace chemical fuels if extra-terrestrial flight is to be achieved; there are no other serious difficulties other than the financial one."

reduction in costs. Twenty years should see these problems solved.

The problem of safety for aircraft is largely psychological. It is notable that "safe" small aircraft do not sell. People do not buy small aircraft because they are safe; they buy them to inflate their egos and therefore the more dangerous, the better. The psychological attitude is similar to that of mountain climbers and hot rodders. And if everyone were properly adjusted, none of these would exist. There is something to be said for teaching every young man to fly, if it is possible to do it without terrific carnage. Unfortunately, the accidents don't always involve only the pilots.

This Activity is also concerned with aircraft accessories. It is safe to say that within another 50 years most of these devices should work. Some of our present accessories, such as capacitance fuel gages, being based on unsound physical principles, will be replaced. Fifty years from now most of these gadgets will be about as reliable as telephones are now.

Our present instrument flying system must be replaced by something less confusing. Twenty years of trying to get a satisfactory instrument arrangement should prove to anyone that our present system is unsound psychologically and physiologically. The pilot must be given a 3D television type of presentation in the windshield so that he will have a natural view of the situation. Anything less does violence to his instincts. In 50 years we can hope that the uniformity of design so typical of a mature industry will appear in these accessories and their functioning.

We can expect a great deal of progress in metal-

ON HELICOPTERS . . .

". . . mere contact with another helicopter can be fatal. These infuriated windmills will destroy each other like creatures in a nightmare."

lurgy. Duralumin as an alloy is not yet 50 years old. We can probably expect greater developments in this field than in many others, since the metallurgists are just beginning to come out of the kitchen and to do their thinking at desks. Our structural alloys should be at least twice as strong as the ones we are now using; the nonmetallic materials will also be improved in an even greater ratio.

As consequence of the improved materials, improved manufacturing and assembly techniques our aircraft 50 years from now will be as superior to our present best performance as today's aircraft are to those of the World War I. These aircraft may be made of metal, or they may not. Some of the properties of long fully saturated molecules are surprising. Who knows, within 50 years perhaps someone will even come up with a non-destructive method for the measurement of incipient fatigue failure.

ON FUTURE ENGINEERS . . .

"Basically these people (will) need the scientific background of a physicist with the practical approach of a mechanic."

We can expect engineering departments of the future to be differently organized. The problem of large engineering organizations operating on a small number of products is a new thing in human experience and as yet no standardization has developed. Let us consider the engineering organization of the future to be headed by a chief engineer and his immediate assistants: the sum of his detail duties may be divided among several groups. A partial listing of these follows:

I. **Internal Affairs**
   1. Personnel
   2. Housekeeping
   3. Clerical services

II. **External Affairs**
   1. Customer contacts
   2. Project coordination
   3. Field service
   4. Licensing agency contacts

III. **Engineering**
   1. Intelligence
      a. Aerodynamics
      b. Structures
      c. Stress analysis
      d. Loads
      e. Weight
      f. Systems analysis
      g. Powerplants and thermodynamics
      h. Human engineering
         1. Acoustics
         2. Physiology
         3. Comfort and safety engineering
      i. Testing and research

   2. Design
      a. General
      b. Special
         1. Structural
         2. Mechanical
         3. Electrical
         4. Thermodynamic
         5. Fluid mechanics
         6. Controls

   3. Services
      a. Applied mathematics and computing
      b. Analog machines and simulation
      c. Metallurgical and material services
      d. Production design
      e. Technical information
      f. Miscellaneous consultants

IV. **Research and Testing Facilities**
   1. Aerodynamics
   2. Structures
   3. Electronics
   4. Electrical equipment
   5. Mechanical equipment
      a. Hydraulic
      b. Pneumatic
      c. Powerplant
      d. Miscellaneous
   6. Simulation
   7. Flight research

It will be noticed that all the information for the shop originates in Section III, 2; the only part of the entire department that makes drawings and transmits other information to the manufacturing organization. This group, which must weigh the information given to it by the other parts of the engineering department and must make the basic decisions which determine the general and specific nature of the product is now inadequately educated, staffed, and supported.

In order for such a group to work at all, and for an organization to come up with sensible results, the members of this group must have an adequate training in evaluating the opinions of specialists. This means that this group requires a more complete, and broader education and training than that of any of the specialists groups. Basically these people need the scientific background of a physicist with the practical approach of a mechanic. They need knowledge and skill capable of determining the optimum design in a multidimensional field.

These men are frequently in the position of a

ON SALES

AND PSYCHOLOGY . . .

"It is notable that 'safe' small aircraft do not sell. People do not buy small aircraft because they are safe; they buy them to inflate their egos and therefore the more dangerous, the better. The psychological attitude is similar to that of mountain climbers and hot rodders."

ON METALLURGY FUTURES . . .

"We can probably expect greater developments in this field than in many others, since the metallurgists are just beginning to come out of the kitchen and to do their thinking at desks."

family physician who can according to the advice of specialists, have his patient's teeth pulled, operate on him for appendicitis, have him given pyschiatric treatments, or put him on a special diet. The future education for these people will be discussed later.

Fifty years from now the designer will be much more of a mathematician than his present counterpart. He will be used to large calculating machines, and familiar with the characteristics and capabilities of analogs. He may work at his desk with a miniaturized multidimensional analog and solve some of his polydimensional and non-linear problems directly. It is difficult for us in the kindergarten epoch of the art to realize what 50 years will bring.

The designer will think in terms of rates, not of magnitudes; problems will not be approached by sampling but will be optimized. Problems will be formulated in terms of physically independent variables and not in terms of meaningless parameters. (The writer has come to the conclusion that a parameter is something that is used by a specialist to confuse his readers.) These aircraft design problems will contain from 50 to 100 independent variables. The solution in terms of the desired operating characteristics, such as take-off run, maximum speed, cost per ton mile, and so forth, will determine the values of the wing thickness, the sweep back angle, the wing area, the span, and so forth.

A further investigation will be made to determine the sensitivity of the results to variations in the excellence of manufacture and the quality of the detail design. A further study of the effects of powerplant growth and of changing economic conditions will permit an adequate evaluation of the probable economic success or failure of the design.

This method can be applied to any products the characteristics of which can be expressed by mathematical relations. At the present time it can only be used where comparatively simple functional relations can be found. Let us give the mathematicians the next 50 years to produce better methods.

ENGINEERING EDUCATION

The engineer of the future will be much better educated than his present day counterparts.

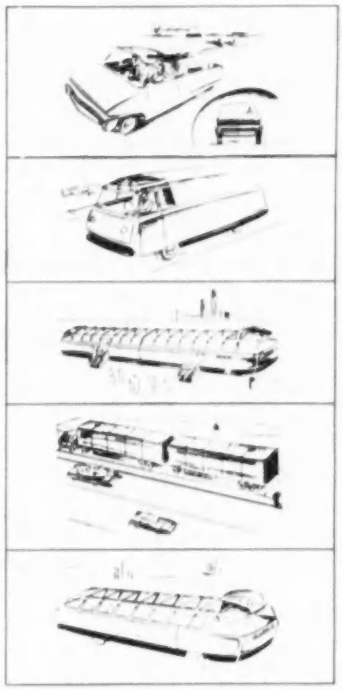
- He will have a solid foundation in the basic sciences, and will in addition be given a background in economics, industrial management, and psychology.
- He will be trained in conveying ideas, both upward and downward in his organization.
- He will know that the number of geniuses available in the industry is effectively zero.
- He will know that materials do not maintain fixed dimensions.
- He will know that neither mechanics nor pilots can be expected to give continuous and unfailing attention.
- He will know that all devices fail and what failure rate to expect from different kinds of equipment.
- He will be immune to false objectives such as "do it electrically."
- He will recognize from his psychological studies when he, himself, is prejudiced and in important cases will accept good suggestions even if they come from disagreeable individuals.
- He will know the fields in which he is competent and will not hesitate to ask for help in others.
- He will be trained to recognize the cycles in human optimism and pessimism so that he can evaluate his performance properly.
- He will not be pressured into making impossible commitments, and he hopes that his customers have reached the state where they do not need to be bolstered up by false expectations.

Education to prepare the designing engineer for his job will consist of an academic training roughly equivalent to that for a present day Ph.D., plus an internship under careful supervision.

The men who are to exercise judgment and to compromise the differences between the specialists must be carefully trained. They must understand not only the basic facts involved in each specialty, but also must understand the personalities of the individuals concerned, and how far to believe them. In order to get the time to train these people, a new synthesis of the scientific background will occur and the old breakdown into specialities will be avoided.

ON PARAMETERS . . .

"A parameter is something that is used by a specialist to confuse his readers."



Future Trucks and Buses

THE LOOK Ahead
1905 A GOLDEN ANNIVERSARY ARTICLE 1955

by C. A. Lindblom

SIGNIFICANT advances in trucks and buses will evolve from the engineer's arduous quest for better end-product efficiency during the next 25 years. Future trucks and buses will be an integrated byproduct of minute refinements in the many vital components that comprise their assembly.

Economics and practicability will play an important part in determining what can be done and how. Political and social conditions will dictate if and when a development can become a production reality. War, for example, will tend to stymie progress in commercial trucks and buses. Peace, on the other hand, will intensify competition. In either case, with advanced standards of living and education for a growing population, Mr. Customer will become more discriminating. And cost will always predominate as a common denominator of product evaluation.

Just what will be done to improve the efficiency of trucks and buses in the next 25 years depends a lot, therefore, on these influencing factors. However, it seems likely that:

• Availability of 100-octane fuels, together with other engine refinements, may boost fuel economy of spark-ignition engines by 25 to 30%.

• Quarter-ton pickups will become very popular with farmers and small tradesmen.

• Future city service trucks will have lower floor heights for ease of loading and unloading, shorter wheelbases for better maneuverability, push-button-controlled doors, power steering, power brakes, and automatic transmissions.

• Transit buses will seat 100 passengers . . . and be operated by only one man.

• Lazy metal will be given its walking papers by designers of highway hauling vehicles.

• Even the heaviest highway vehicles will be capable of a sustained speed of 15 mph on a 6% grade.

• The trend will be toward bigger trailers and multi-unit trains rather than toward single trucks.

• Intercity buses may be equipped with air conditioning, "stratodome" observation decks, washroom facilities, radios, and improved level-ride suspensions.

• Off-highway vehicles will cater more to driver comfort and ease of handling.

Obviously, any blueprint for future trucks and buses must encompass a broad range of end product requirements. Yet, final analysis of the bill of material will reveal a striking similarity of components in all trucks and buses, particularly with regard to powerplants and running gear.

Please turn page

Spark-Ignition Powerplants

Considerable speculation prevails regarding the types of future powerplants. From all indications, the spark-ignition reciprocating engine will predominate. Diesels will follow, and eventually, gas turbines will begin to make inroads in specialized high-powered applications.

The dynamic impact of the passenger car industry on spark-ignition engine development and its accelerating effect on production of higher octane gasolines must be recognized as a potent economic factor governing the future trend. It would be presumptuous to predict that the deep roots of capital investment, from which these branches of industry stem, will be supplanted because of radical innovations in engine design in the near future. Volume production is conducive to low costs. Therefore, the present transition to high-output V-8 engines points to the use of gasoline for the majority of trucks for some years to come.

The advantages of high-octane gasoline in contributing to improved engine efficiency are well known. With fuels of 100 Research octane number commercially available in the offing, the gap between the spark-ignition engine and the compression-ignition engine will tend to close, particularly at the high load factor. Compression ratios of 10:1 will be common. Also, the spark-ignition engine will have an advantage in power production per unit of engine weight and displacement, since it burns all of the air charge, whereas the diesel engine burns only about 85% of it.

Combined with other refinements such as increased combustion, volumetric, and mechanical efficiency, plus optimum carburetion, an overall improvement of about 25 to 30% in fuel economy should be expected in truck and bus operations.

The possibility of fuel injection will be fully explored, together with supercharging for better specific output, particularly for highway transport.

Engine sizes will range from 100 to 300 hp normally aspirated and up to 400 hp supercharged. Although rotative speeds will approach 4000 rpm, even in the

SAE Golden Anniversary Author

C. A. Lindblom has been with International Harvester Co., Motor Truck Division since 1949, as divisional chief engineer in the Fort Wayne Plant.

Lindblom is a native of the copper country of northern Michigan, born in Laurium in 1904. He studied mechanical engineering at Wayne University and also took extension courses in advanced mechanics and strength of materials at the University of Michigan.

In 1925 he joined General Motors Research Laboratory as a designer. He remained with GM 12 years, rising to the position of assistant head of the automotive design section. His next move was to Gothenburg, Sweden, where he joined A/B Volvo as assistant chief engineer. He served in the passenger car division in the Gothenburg plant and then came back to Detroit in 1940 to serve as consultant and buyer for Volvo.

During the war Lindblom continued his engineering career in the Office of the Chief of Army Ordnance as chief, Armored Vehicle Group, Engineering-Manufacturing Branch. During his term of service, he spent seven months in Europe on a special mission.

C. A. Lindblom

Upon returning to industry, Lindblom rejoined A/B Volvo in Sweden as chief engineer in the passenger car division. Then in 1946, he left A/B Volvo to become chief engineer for the White Motor Co., Cleveland, Ohio. He worked with White until he went to International Harvester in 1949.

Lindblom joined SAE in 1951 and has been a very active member. He has served as meetings vice-chairman of the Truck and Bus Activity Committee for the past year. He has also presented papers on the subject of hydraulic drives before many SAE Section meetings.

large truck engines, piston speeds will be held below 2500 fpm to insure reliability and longevity.

In certain areas, the LPG version of the spark-ignition engine will be popular due to availability and low cost of fuel.

The elimination of liquid cooling will always be a moot subject. Its advantages from a military standpoint are recognized for all type piston engines. However, unless prompted by military demands, little effort is expected to be concentrated in this direction, other than perhaps a continuation of existing aircooled, spark-ignition engine developments.

Compression-Ignition Engines

Despite the tremendous impact of newly designed spark-ignition engines in the automotive field, the inherent high thermal efficiency of the diesel will make it supreme in many operations where the space-weight-to-power ratio requirement is secondary to fuel costs . . . for example, on off-highway equipment. In addition to better fuel economy, the diesel engine has lower cost per gallon of fuel.

However, there are indications that the difference between gasoline and diesel fuel costs may diminish by virtue of increased demands for distillates in jets, turbines, railroad diesels, and heating oils. Since all of these fuels must come from the same barrel of crude, the demand for distillates must be met by the addition of substantial quantities of cracked stocks. Cracked stocks are more expensive to manufacture and may require the use of cetane improvers to secure satisfactory engine operation.

This economical aspect, exclusive of any political tax equalization probabilities, could offset all of the basic engineering advantages related to high thermal efficiency and render the diesel unattractive.

The diesel engine potential for motorized rubber-tired equipment appears to lie in a category of engine sizes ranging from 200 to 600 hp. These increased output engines must be complemented with higher capacity transmissions and drive-line components. The development, tooling, and manufacturing of limited quantities will be prohibitively expensive compared to mass production items. Therefore, economic and practicabilty considerations will tend to circumvent such programs as much as possible, while encouraging the exploitation of existing units in multiple combinations as is already apparent in some dual-engine installations and twin-transmission arrangements.

For the long pull, it appears as though more efficient diesel operations will result from design refinements rather than improved quality of fuel. That's because little would be gained if fuels of above 50 cetane number were available.

Much research will be concentrated on improving combustion efficiency and in reducing the engine package size, weight, and initial cost. The possibilities of the exhaust-driven supercharger will be exploited to the limit.

Gas Turbines

Considerable interest will be centered on gas turbines, and much progress can be expectd by virtue of forthcoming processing techniques and development in high-strength, heat-resistant materials.

Lightweight turbines will be mechanically possible in the near future. But low thermal efficiency and high initial cost will probably preclude their extensive use in trucks and buses during the next 25 years. Where size is not so important, substantial improvements in efficiency will be obtained through heat exchangers, intercoolers, and regeneration.

For this reason, gas turbines in automotive equipment will lag behind the large power installations, such as locomotive and stationary powerplants. In all probability, the first automotive application will be in long distance intercity buses.

In the last analysis, the selection of powerplants will be based on economic considerations weighed against end-product usage. The significant fact remains that the improvements in processing and materials, prompted by gas turbine development, will concurrently favor the piston engine.

Power Trains

In striving for maximum efficiency, modern thinking must consider the power train as an integrated system rather than a combination of independent units, such as engines, transmissions, drive line, and final drive. It is the power at the wheels that counts. In this modern age, the lack of accurate data in the truck and bus field on as-installed engine outputs, power train losses, and net tractive efforts between the driving tires and road is appalling. The corrected bhp figures and drive-line efficiencies of laboratory conditions, with which so many are prone to deal, rarely occur in actual vehicle operations. It takes over an hour of continuous road operation to stabilize power-train lubricant temperatures, a condition which is never reached in many operations.

The viscous drag of heavy lubricants in bearings, seals, and multiple gear sets, the parasitic losses in

accessories, and tire hysteresis are variables—their cumulative effect can reach alarming proportions if measured under certain conditions.

The advantages of matching modern, high-speed engines with proper gear ratios and steps, shiftable under power automatically or with mechanical overrule, plus the need for heavy-duty, low viscosity, high V.I. lubricants, are too obvious to be overlooked. Therefore, engine-power-train compatibility will be the subject of major engineering activity in the immediate future.

Before predicting what's in store for specific kinds of trucks and buses, it would seem logical to classify these vehicles according to the type of operation for which they are intended. Broadly, four categories become apparent:

(1) general purpose,

(2) city service,

(3) highway hauling,

(4) off-road operations.

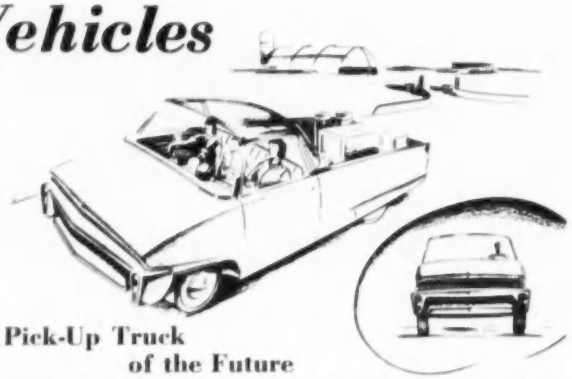
General Purpose Vehicles

Economics in the next 25 years will make the ¼-ton pickup very popular with farmers and small tradesmen. Low initial and operating costs will be the salient attractions. However, contemporary styling, appointments, and riding comfort on a par with passenger cars will be demanded, too.

Small, high-speed powerplants will keep pace with the performance requirements of the times. Power output will be restricted to about 100 hp, with emphasis on part-throttle fuel economy.

Curb weight will be about 2500 lb. This will be accomplished through more efficient use of material in the cab and power train.

The panel-delivery and high-platform trucks in today's city service will be superseded by specialized versions which will be more suitable for their respective jobs.



Pick-Up Truck of the Future

City Service Trucks

Two types of city service trucks will predominate in the future:

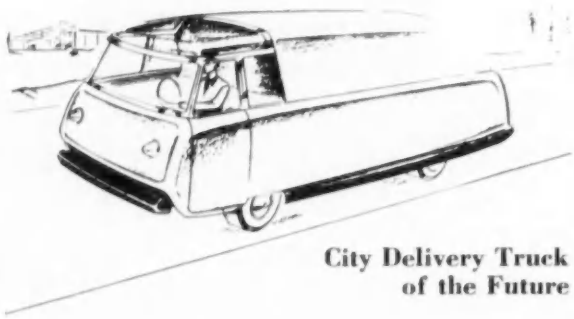
1. the multi-stop-standee drive, and
2. the low-entrance COE.

The multi-stop trucks will be confined principally to the delivery of milk, bread, groceries, laundry, flowers and general merchandise. They will range from 5000 to 12,000 lb Gvw.

Typical uses for the COE will be single-stop, heavy hauling such as oil, coal, lumber, drayage, furniture; also, dump trucks, cement mixers, and specialized muncipal utility trucks. Because of their load-carrying ability, low-entrance COE's will be used by bottlers to some extent for multi-stop delivery service. Gross vehicle weights will range from 14,000 to 40,000 lb.

Utility will be the most important requirement for city operation. Future trucks will be better fitted to their jobs so as to render efficient and reliable service, conveniently and economically.

Improvements will be effected in ease of loading and unloading, optimum use of space, uniform weight distribution per tire, and short wheelbases for maneuverability. Even 8-wheelers with small diameter tires and two or three steerable axles may gain acceptance in the U. S. for heavy transport in congested areas.



City Delivery Truck of the Future

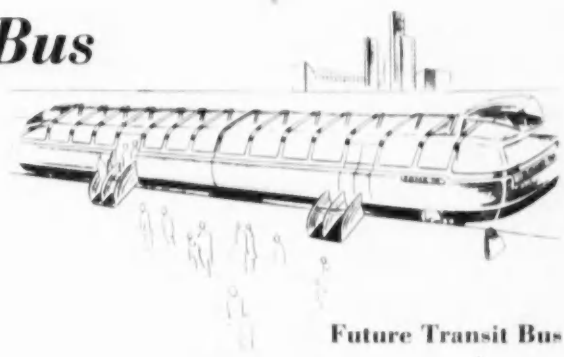
Because of the large number of stops and starts in city traffic service, engines idle as much as 60% of the time. Thus, fuel consumption and clutch troubles are relatively higher. Alleviation of these conditions points toward the use of small high-speed engines, with hydrodynamic planetary transmissions and high numerical engine to axle speed ratios.

Much will also be done to reduce the tare load of these vehicles. A large percentage of the weight of

the present multi-stop vehicle is in the body. Its main function is to protect the cargo. It adds little to the load-carrying structure of the truck. Hence, the body will be an excellent field for exploitation of lightweight reinforced plastics.

With as many as 200 stops per day, comfort becomes an important factor in maintaining a pleasant sales attitude of city truck drivers. To accomplish this objective, the multi-stop truck of tomorrow will have lower floor heights, power steering, automatic transmissions, pushbutton-controlled doors, and power brakes.

City Service Transit Bus



Future Transit Bus

The transit bus is a unique example of a city service vehicle developed primarily to do a specific job more efficiently.

In many respects, the future of the transit bus appears to be dependent on Mr. Citizen's solution to a self-inflicted social problem: unprecedented traffic congestion brought about by the 500 to 1 ratio of automobile to mass transit vehicles. The political and economic implications of this mass transportation situation make it more frustrating where municipal ownership of transit systems is involved. In the final analysis, Mr. Engineer will be called upon to bear the brunt of the responsibility for effecting a practicable solution.

To provide speedier service, some planners visualize separate transit lanes on expressways, or even private right-of-ways which radiate from the center of the city to strategically located parking areas spotted on the outskirts of the city limits.

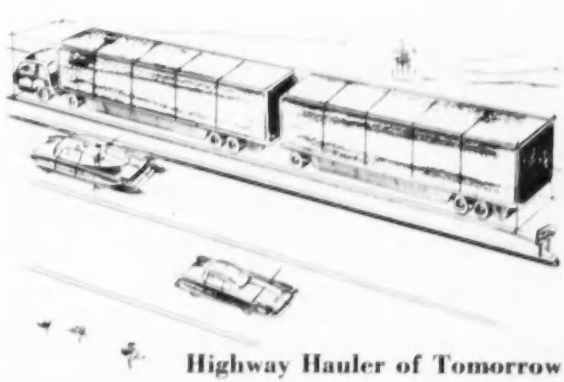
Then 100-passenger-capacity buses or trains of several coupled units with standees eliminated will be practical. Side-door entrance from loading platforms with mechanical turnstile fare collectors, combined with central address systems and push-button controls will enable one-man operation. Schedules will be controlled by automatic signal devices enroute. Some of the more daring soothsayers even go so far as to predict complete supersession of the transit bus by subways, the monorail system, and even helicopter service to suburban areas.

Although the transit bus has had its ups and downs in a rather short career, it seems reasonable to assume that the mobility of the self-propelled bus, combined with a network of modernized traffic lanes, should provide the most flexible system for mass transportation. The imminence of the civil defense situation and the need for evacuation highways from cities emphasizes this thinking.

It appears then that the transit bus will continue to serve the public for a long time.

Furthermore, the transit bus engineer's basic thinking in performance, utility, comfort, and safety will perpetuate, and the many innovations already pioneered will progress. Among them are the monocoque stressed skin construction, lightweight materials, torque converter transmissions, power actuated controls, thermostatically controlled heating and fresh air conditioning, low variable-rate, easy-ride suspensions with torsion rod, rubber, or air systems, foam rubber seats, washable synthetic upholstering, engine fume degassers, noise insulation, and better driver visibility.

Highway Haulers



Highway Hauler of Tomorrow

Growing competition from other forms of transportation will intensify the demands of highway haulers for motor transport equipment that will haul more payload faster and more economically.

Legislation may well be the dominant factor which will control the direction of long-range development.

More uniformity in size and weight regulations

among the 48 states can be expected, however. The cooperative efforts of the Highway Research Board, the American Association of State Highway Officials, Bureau of Public Roads, and the many other organizations interested in the development of highway transportation and the National Highway System, will have provided basic data for determining economical limitations in truck sizes and weights.

Bureau of Public Road data shows that cost per ton-mile of payload decreases as gross vehicle weight increases. It is logical then to expect the trend toward adoption of a higher gvw as the first step to more economical transportation.

If the "guesstimate" of 25,000 miles of interurban toll expressways materializes in the next 25 years, it is conceivable that highway transportation will divide into two separate operations—short distance and long distance hauls.

Long distance transportation on express highways will be handled by tractor-trailer combinations with two or three large semitrailers. The rear trailers will be supported by fifth-wheel dollies. The two-trailer combination will be 85 ft long and have a gcw of 110,000 lb. The three-trailer train will be 125 ft long and have a gcw of 160,000 lb.

These large combinations will operate only on the expressways. At the nearest interchange to their destination, individual trailers will be uncoupled and others picked up. The second operation will be the distribution of individual semitrailers by small tractors via public highways.

Practicability of this bilateral highway transport scheme is indicated by the fact that, first, it complies even with present public highway axle-weight and tractor-trailer length legislation. Secondly, by virtue of long easy curves and passing lanes on hills, future expressways will have eliminated any objections to tracking of multiple trailers and impediments to speedy traffic flow.

Many operators claim that a pound reduction in tare load is worth about $1.25 annual revenue because it provides an extra pound in payload. Take for example, an average freight haul of 300 miles with a rate of 40¢ per cwt. On the basis of 90,000 vehicle miles per year, the amount of revenue per pound would be $1.20. For a 500-mile haul and a 60¢ per cwt rate, it would reach $1.80 per lb per year. In 1000-lb increments, the return is appreciable.

It is evident, therefore, that low tare weight will be an everlasting objective. By merely pegging the ratio of payload to gcw at 80%, truck and trailer engineers will have their work cut out for them for a long time to come.

A cursory weight analysis of components reveals a conspicuous example of lazy metal. The cab, which weighs four to five times as much as the driver, is a good place to start. In this respect, modern experimental stress-measuring techniques will be a boon to the engineer in effecting more efficient distribution of materials. Structural redundancies will be eliminated. Practicable and economical avenues to lighter metals and plastics will be clear cut. In addition, suspensions and tires, respectively, will provide fertile fields for exploration. Much will be done to achieve greater energy-absorption-capacity per pound of material. Supplementary assists from air or hydraulics will offer possibilities.

The common carrier cannot select cargo discriminately. Consequently, cargo space is becoming as important as payload.

Legal restrictions on length, height, and width establish a phantom box into which a tractor-trailer combination must fit. On present equipment, cargo space rarely exceeds 50% of this theoretical allowable volume. This percentage might be termed the cargo-space efficiency factor. Take for example, a tractor-semitrailer combination of 45 ft overall length pulling a 35-ft trailer with 12½-ft height and 8-ft width. Even with one of the latest "Hi-Cube," square-nosed trailers, cargo-space efficiency factor represents a ratio of only 2300 to 4500, or about 51%. With a 59,000 lb gcw and a 68% payload factor, this would yield a payload density of 17.4 lb per cu ft for 100% utilization of cargo space, which roughly is equivalent to a full load of the lightweight types of green produce.

Obviously, the simplest means of obtaining more cargo space is to increase the length, height, and width dimensions. However, legislation has curtailed such action on the part of the engineer in the past and undoubtedly will continue to do so in the future. To what extent this is done remains to be seen.

Nevertheless, the engineer will be challenged to produce more cargo space within restricted dimensions. The target will be tough to hit, if he sets his sights at a 60% cargo-space efficiency factor.

Shippers choose truck transportation because it is readily available, fast, and economical. However, the competitive advantage of portal-to-portal delivery by truck over the time-consuming routine of switching cars in railroad freight yards may diminish as the "piggyback" idea of hauling trailers by railroads gains a foothold. This will focus greater attention on performance, which, in general, implies higher power-weight ratios.

Although speed is a very important factor in transportation, it is expensive because road horsepower requirements increase approximately as a square of vehicle speed. Therefore, economic considerations will dictate that top cruising speeds be restrained to about 50 mph.

Efforts will be directed toward raising the average road speed by using better power-weight ratios to improve acceleration and hill-climbing ability. The hydrodynamic drive automatic transmission, capable of being shifted under power, will play an important part in this respect. It will permit the engine to operate at its most efficient output range at all times and will automatically respond to the demands of the wheels as directed by the driver through manipulation of the accelerator. Probably, the toughest performance demands will be encountered in hill climbing.

It is likely that even the heaviest highway vehicles of the future will be capable of a sustained speed of 15 mph on a 6% grade. This will require about 1 hp per 300 lb of gvw.

Safety consciousness will always pervade the minds of the truck driver, owner, and engineer. For this reason, much progress is anticipated in reducing driver fatigue, improving visibility, and increasing brake system effectiveness.

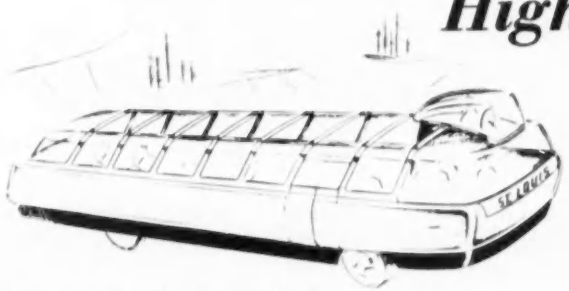
In an effort to improve public relations, much will be done to effect better silencing of mufflers, tires,

fans, and the induction system. Also, means for reducing exhaust smoke and odors will be given considerable study. Possibly, catalytic inducement of complete combustion of gases in the muffler may be the solution to the latter.

The trend to bigger trailers and multi-unit trains will gain momentum over single trucks under the competitive pressure for lower hauling costs.

The optimum space-weight-time relationship of highway transportation will be a continuing challenge to engineering ingenuity to maximize cargo space, minimize tare weight, and reduce the cost of power requirements. Every possibility for incremental gain in efficiency will be exploited. Consequently, as the point of diminishing returns approaches the tangible limits of legislative bounds, the gleanings will be increasingly difficult to find. Therefore, considerable attention will be directed toward studies of drive-line efficiencies, particularly transmissions and rear axles.

Highway Intercity Buses



Tomorrow's Intercity Bus

In all probability, the requirements for intercity buses will continue to increase as population expands. However, as in the case of the transit bus, competition from the private passenger car is being felt. Therefore, passenger comfort, luxury appointments, and low cost fares will be focal points of future development to lure more patronage.

Air conditioning, better seating with "stratodome" upper level observation decks, washroom facilities, radio, and improved silencing will be some of the attractions. Work will continue on suspensions that will automatically adjust to varying vehicle load.

Top speed will remain about the same as today. In the interest of performance, tare loads will be reduced; finger-tip controls and automatic transmissions will be standard.

Although widespread use of turbines for powerplants is not predicted, it is entirely possible that some type of lightweight turbodrive will be used as a power source for lighting, heating, and air conditioning systems.

Off-Highway Heavy-Duty Trucks

It appears as though the trend to large off-highway heavy-duty trucks is leveling off. This is because the point of diminishing returns is being approached as trucks exceed 30-ton capacity, due to the accompanying increased road maintenance costs.

Specialized heavy-duty rear dump trucks will continue to be built in about three sizes: 15, 25, and 35 tons. In each size, there will be a counterpart tractor version for bottom dumps, scrapers, and logging rigs. Horsepower requirements will be about 200 for the smallest, 300 for the intermediate, and 500 for the large size.

Diesel engines, which have gained a firm foothold in this field, will continue to be very popular. Although twin-engine installations are an economic means of accomplishing the high horsepower requirements, it appears as though the single-engine installation will win out eventually, particularly if compatible power-train components become available.

Hydrodynamic converters will continue to be popular. They eliminate clutch "frogging" and reduce power-train shock loads and, hence, lower maintenance costs.

Both the 4 × 2 and 6 × 4 type vehicles will be used. Where maneuverability and cramped working areas prevail, the 4 × 2 will be the choice. This will be so because tire costs, the number one maintenance item, is always higher on six-wheelers due to more tire scuffing on turns.

Frames and bodies will continue to be very rugged to handle the dense and jagged materials normally hauled. However, considerable thought will be given to reducing tare weight by using lighter gages, particularly in the coal fields.

Driver comfort will be recognized as one of the most important factors for efficient operation. Cabs, seats, and ventilation will be improved accordingly. Location of instruments and controls will be standardized. Power steering will be adopted universally, even on the smallest off-highway vehicles.

In brief, the perspective of future trucks and buses will be an evolution of past progress correlated with present happenings and future conditions. Efficiency will be the keynote. And progress will result from adherence to modern scientific methods of engineering merged with concurrent achievements in materials, fabrication processes, fuels and lubricants.

Economics will dominate the trend with competition as the motivating catalyst.

Sound Tractor and Farm

Then . . .

Photo: F. Hal Higgins' collection

Fig. 1—Combines pulled by 28 mules in team formation were stiff competition for steam and gas traction engines in the early 1900's. A "bull wheel" on the combine furnished power to operate the harvesting and threshing machinery

. . . and Now

Fig. 2—The tractor power take-off shaft, universally standardized by the industry, supplies power from the tractor engine to operate many kinds of drawn implements, especially bulky harvesting machinery carried on its own wheels

Machinery Future Grown from Varied Past

by C. E. Frudden

THE nearly five million tractors on farms and in construction camps today—and the half million new units being produced annually—assure agriculture and the construction industry the same benefits of suitable power enjoyed by industry generally.

The historical development of the tractor has been continuous but generally hard earned. A good example of the problems encountered which hindered progress was the lack of an air cleaner for keeping abrasive dust out of the engine cylinders. First, it was necessary to recognize the need for such a device, which was an entirely new idea. Then an appliance to do the job with a high degree of efficiency had to be developed. Suitable air cleaners came along just in time to save the tractor industry from reverting back to steam or of passing out of the picture entirely.

Today the farm machinery industry is engaged in a huge program for the interchangeable mounting of many types of implements on tractors. Standardization, so far, is largely on an intra-company basis. But this opens up a new opportunity for greater standardization of attachment or "hitch" points between tractors and implements on a broad industry-wide scale.

The nature of modern farm enterprise demands a high degree of organization and efficiency during critical periods of crop production. Experience has taught many farmers that reliance on power machinery offers the greatest asurance of success. This has resulted in more favorable consideration for special-purpose, self-propelled harvesting machines of various types, establishing a trend contrary to the long-standing popularity of general-purpose, universal machinery for mounting on or being towed behind standard tractors.

To more economically carve out tomorrow's superhighways, to expedite lumbering, engineering construction, oil production, mining, and to otherwise operate over almost impossible terrain, new and larger track-type tractors and large rubber-tired units have been developed and are taking on new forms.

Diesel engines, which have proved particularly adaptable for industrial tractor service, now dominate the construction field and are presently making inroads among the farm tractors.

Interpreting trends and projecting them into the future may be an interesting pastime to some. But particularly for those in the automotive field, whether tractor or automobile, it can become a hazardous business. I have never forgotten one personal experience back in 1909 when upon our graduation from college, another budding engineer and I laid down for the record our well-considered specifications for what was intended to be the "ultimate" automobile. The specifications included two-cycle engines, aircooled cylinders, high wheels, solid rubber tires, and friction transmissions—all five items being in popular favor by many authorities at the time.

But as wise men have said before, "Everything depends upon everything else and vice versa." How true! In our case, improved roads and better pneumatic tires wiped out the high wheels and their solid tires. Quiet, efficient, and easily-shifted gear sets eliminated the friction transmissions and the better performance of water-cooled, four-cycle engines, in spite of their mechanical complications, relegated the two-cycle, aircooled engines to the discard heap. Our record for these forecasts to date: no hits, no runs, and batting average—zero.

The "tractor of the future" has been just as un-

predictable to date as was our automobile in 1909. It will no doubt continue to be so because of the fact that everything does continue to depend upon everything else and vice versa.

How It Started

Founding of the tractor industry is generally accredited to two young men, a short time out of college, who had established a small factory for building gasoline engines in Charles City, Iowa. Gasoline engines at the time were still quite a novelty. In 1902, these two young men, operating as the Hart-Parr Co., built and sold their first tractor. They followed up in 1903 by the sale of 15 more like it. Thereafter, sales continued at increasing rates even to the present time, Hart-Parr becoming one of the parties to the present Oliver Corp., a full line company.

Another pioneer, who also left his mark indelibly on the tractor record was Benjamin Holt of Stockton, Calif. Not satisfied with the performance of tractors equipped with large-diameter, wide-rimmed steel wheels, he, in 1904, built his first steam-powered, track-laying type tractor, placing his gas-powered product on the market shortly thereafter.

In these crawler-type machines, we find the ultimate in ability to furnish both flotation and traction, especially when working in soft ground or under otherwise poor conditions for obtaining secure footing.

Drawbar pulls up to 85 to 90% of tractor weight, obtainable with these tractors, set them apart from the more common wheel-type farm tractors. Earth-moving and construction contractors turned to these machines for their pioneering projects, while the field of agriculture became a secondary outlet for crawler tractors. Like Hart-Parr, the Holt Co. also has continued to carry on through the years, becoming one of the parties to the present Caterpillar Tractor Co., of "Earthworm Tractor" fame.

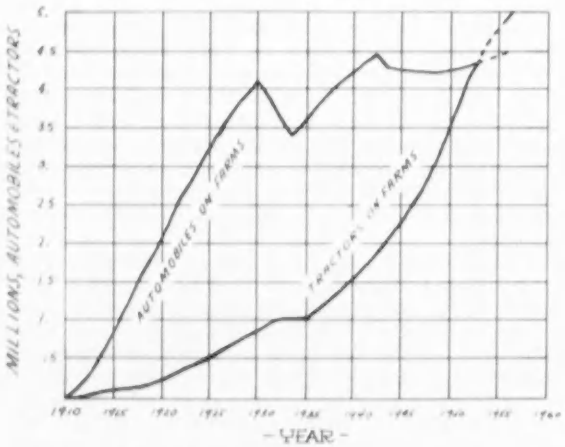


Fig. 3—Farmers "took" to automobiles faster than to tractors, but as the horse population began to disappear, tractor activity moved into high gear, to a point where tractors now exceed the number of automobiles on farms

More recently, off-the-road, rubber-tired tractors with self-loading scrapers and large-capacity trucks have appeared to challenge the crawler tractor, particularly for the longer hauls. But in many more cases, the two types of machines supplement one another. The crawler tractors furnish the pushing power for loading scrapers and the rubber-tired vehicles transport loads to fill at relatively high speeds.

Horse-drawn plows, harrows, and grain drills as well as harvesting and threshing machinery were in highly-developed form. Slip scrapers, road graders, and elevating graders were developed for moving dirt to build roads, dams, and levees. But one element was lacking for big scale operations, that was suitable power. Horses and mules, from single animals to teams of 30 or more, furnished the best to be had (see Fig. 1 and contrast with today's equipment in Fig. 2). But with speeds limited to 2 mph and frequent rest periods required during the day's work, progress was slow and the work done was expensive.

A small number of steam traction engines was built during this period to furnish power for operating threshing machines and moving "outfits" from one field to another. But the several problems besetting use of steam traction engines on farms definitely limited their usefulness. Ponderous and difficult to maneuver, they were handicapped for field usage and the problem of obtaining suitable boiler feed water was almost insurmountable. Hard water produced scale on boiler tubes; overheating and even boiler explosions were not at all uncommon.

Into this picture came the gasoline "traction engine" during the early 1900's. It introduced a new type of power, free from excessive weight and serious water problems. It operated threshing machines by belt transmission satisfactorily and could be adapted for pulling loads at the drawbar—implements such as plows, harrows, grain drills, and harvesting equipment as used in the big wheat country of the West.

Steam tractors passed out of the picture as fast as gas tractors moved in.

Inherently, however, the internal combustion engine had one vulnerable weakness. Dust entered cylinders with air and fuel mixture supplied by the carburetor. This resulted in rapid wear of cylinders, piston rings, crankshaft bearings, and so forth. L. B. Sperry in an SAE paper,[1] reporting on his early tractor experiences, stated:

"This problem of engine cylinder, ring, valve, and bearing wear from dirt entry became so acute a trouble to the tractor industry that approximately around 1920, we (International Harvester Co.) developed and built a uniflow-type steam engine and fully enclosed condensing system for the engine and boiler needs to have ready if the internal combustion engine could not be made durable."

It took a long time to develop air cleaners of high efficiency. But they came along in time to save the industry from reverting to steam—a vital and

[1] Paper "Farm Power and the Post-War Tractor" by L. B. Sperry, SAE Transactions, Vol. 52, No. 11, November, 1944, pages 501–510, 518.

timely contribution to improved tractor-engine performance.

As steam tractors were retired from use, another and much larger work force remained as a strong obstacle to the ready purchase of gas tractors by farmers. This work force consisted of some 25 million horses and mules raised on the farm and fed home-grown hay and grain from the farmers' own fields. No middle men were involved—no out-of-pocket expense.

But the march was on. The 26 million work animales were gradually reduced to 5 million and the value of a horse on the farm dropped in a 10-year period from $80 (in 100¢ dollars) to $40 (in 50¢ dollars). That phase of the changeover to tractors is now nearly complete. The 50,000,000 to 70,000,000 acres of cropland and pasture required to feed work animals are now available for the production of human food. With the normal increase in population anticipated for this country in the next few years, these recently-made available acres are vitally needed for future food and fiber production.

The horse and mule retarding influence on the purchase of tractors is made clear by the U. S. Department of Agriculture reports of tractors and automobiles on farms from 1910 to date. As late as 1940, farmers owned and operated 4¼ million automobiles, but only 1½ million tractors. (See Fig. 3.) By 1952, there were still 4¼ million automobiles, but also an equal number of tractors on farms. This trend toward mechanization indicates a much faster rate of increase for tractors than for automobiles on farms in the foreseeable future. No question but what the almost complete liquidation of horses and mules has opened up a broader market for tractors and tractor-operated machinery than has existed up to this time.

"Planned Obsolescence"

There was a period when it was fashionable to boast that a given piece of machinery 10, 15, or 20 years old was just as good as a current model. Owners praised its fine construction and reliability, but forgot that obsolescence takes its toll even faster than wear and tear. Now the phrase "planned obsolescence" is heard a great deal. New features, greater versatility, more operating comfort, increased power, and better overall economy obsolete the old and create demand for the new.

At this Golden Anniversary period, it may be in order to reexamine a few of the "new" ideas which have caused the industry to grow to its present size and continue to win more friends.

The greatest forward step in product engineering quite probably came about when the tractor engineers gradually changed their thinking and viewpoints from "gas traction engines" and threshing machines to the new automotive viewpoint. This viewpoint suggested engines with multiple cylinders and relatively high rotative speed, a geared transmission system using precision-cut gears running in oil-tight gearboxes, shafts supported on antifriction bearings, and rubber-tired wheels. This change in viewpoint became more noticeable as the SAE opened its ranks to receive tractor engineers, giving them all the advantages that Society membership had to offer. The automotive influence now com-

SAE Golden Anniversary Author

C. E. Frudden

C. E. Frudden is a consulting engineer with Allis-Chalmers Mfg. Co. He is a life member of SAE, having served as President in 1947 and on many SAE committees, notably the Tractor and Farm Machinery Activity Committee. Frudden has also held the positions of treasurer, vice-chairman, and chairman of SAE Milwaukee Section.

He was born in Ossian, Iowa in 1887 and studied mechanical engineering at Iowa State College, graduating in 1909. He then took advanced courses at Columbia University.

Subsequently Frudden held executive engineering positions with Hart-Parr, Inc., Charles City, Iowa; Parrett Tractor Co., Chicago; Buda Co., Harvey, Ill.; and Allis-Chalmers, Milwaukee. He became chief tractor engineer for Allis-Chalmers in 1929 and has been serving with the company as consultant since 1944. He has studied tractor operations in the field throughout the United States and Canada. He holds patents covering engine accessories and components of tractors and other farm machinery.

During World War I, Frudden served as a captain in the Motor Transport Corps. In World War II, he was a consultant for the War Production Board's Farm Machinery Equipment Branch in Washington.

He was SAE vice-president representing the Tractor and Industrial Power Equipment Engineering Activity in 1938. He has been a member of SAE technical committees in the fuels and lubricants and diesel engineering fields. He is a member and has served as counselor of the Society of Agricultural Engineers.

Fig. 4—Self-propelled harvesting machinery, in the larger sizes, becomes more popular and profitable as farms become bigger and labor more expensive

pletely dominates the field of tractor engineering as it does that of automobiles, trucks, and airplanes.

General-Purpose Tractor Developed

The inception of the general-purpose tractor was a great milestone for the industry.

With tractor farming mechanized for the growing of wheat, the next move was into the Corn Belt with a tractor designed to cultivate corn rows. The tricycle-type tractor with provision for mounting of cultivators opened up new opportunities for row-crop farming.

The same tractor could likewise be adapted to handle all field operations for growing cotton up to the time of harvest, and soy beans, sugar beets, and other crops grown in rows.

Once the cultivator attachment was taken care of, a long list of other implements became available for tractor mounting, including plows, harrows, drills, planters, mowers, corn pickers, and many others.

To date, each company has developed its own independent program of attaching means for implements to tractors. In order to effect quick and easy interchange of implements to tractors, the three-point linkage, the two-point linkage, and even single points of attachment are in use. All provide quick interchange in a matter of seconds for the usual run of implement changes. A glorious opportunity is open to engineers for additional standardization of attachment points so that one manufacturer's cultivator will fit another man's tractor and vice versa. This is no ordinary step, but is well worth serious consideration. It would mean much to farmers using tractors and farm machinery.

The industry's standardized power take-off connection and drawbar hitch point for tractors and trailing implements created wider use of tractor-operated combines, corn pickers, mowing machines, forage harvesters, hay balers, hay rakes, and many other implements. (See Fig. 2.)

Rubber Tires Add to Usefulness and Comfort

Rubber tires for tractors and field implements were the result of automotive influence. Some engineers feel that tractors "on rubber" constitute the number one improvement in tractor design to date. This revolutionary idea greatly improved the tractor's usefulness, added to its capacity for work, and brought the long-sought answer to seat improvement and riding comfort a step closer.

And perhaps more important, with this move it allied tire manufacturers with the tractor industry for further research and improvements. Tires and rims represent approximately 20% of the total tractor cost. The tire and rim standardization program carried out jointly by the rubber industry and SAE Tractor Technical Committee saved both industries large sums of money which might easily have been wasted had there been no early standardization in this new field. From rubber tires suitable for farm tractor service, it was not a difficult step to the development of larger tires required for the earthmoving equipment on contractors' off-the-highway tractors, and also small tires of wheelbarrow size.

Fuel Problems

Fuel problems have bothered tractor engineers from the industry's beginnings. Gasoline taxes, established years ago for building highways, were, correctly or not, also assessed against the farmer for the gasoline he used in his tractor to plow his fields. This tax added appreciably to the cost of tractor fuel. Kerosene and distillates were tax free and cheaper than gasoline. Many years were spent in attempting to adapt these fuels to tractor use. These fuels, however, were low in the octane scale and high in the boiling range which called for low-compression engines and extremely hot intake manifolds. Naturally, specific horsepower was low and fuel consumption high, not forgetting the problems resulting from dilution of the lubricating oil by the unburned tractor fuel.

Engine performance, measured by early Nebraska Test standards, average about 0.08 hp per cu in. and 0.75 lb of fuel per hp-hr. With the gains made possible by the almost universal use of gasoline (regular grade) in today's tractors and the improved gasolines now available, tractor engines are averaging 0.18 hp per cu in. and 0.55 lb per hp-hr. This

means, roughly, that horsepower of a given size engine has more than doubled and fuel consumption reduced nearly 25%. Some of the recent, better-performing engines tested at Nebraska in 1952 and 1953 delivered 0.20 hp per cu in. and consumed less than 0.5 lb per hp-hr. These figures challenge the performance of good diesel engines.

With state gasoline taxes now largely exempted or refunded to farmers when fuel is used in tractors, high-quality fuel is made available at a fair price. The tractor engineer can now take maximum advantage of what the petroleum industry has to offer for improving engine performance and reducing cost. The recent disclosure of engine performance possibilities, if and when fuels become available to operate under 12 to 1 compression pressure ratios, gives the engineer an opportunity to anticipate the future in this direction.

Diesel engines have invaded the tractor field with marked success, their fuel-saving advantages often outweighing their higher first costs by a wide margin. The U. S. Bureau of the Census reports for 1953—a representative year—the production of:

27,300	diesel-equipped wheel tractors
44,000	diesel-equipped crawler tractors
3,041	diesel-equipped contractors' off-the-highway tractors
Total 74,341	diesel-equipped tractors of all types

Stated another way, 7% of all wheel tractors, 85% of all crawler tractors, 100% of all contractors' off-the-road tractors were diesel-equipped in 1953. Further, the 74,000 plus diesel engines used in tractors represent more than 60% of all diesels for all purposes built in 1953. (These figures are for engine units, not horsepower or dollar values.) The diesels have given an excellent account of themselves in tractor service and will very likely take on larger proportions in the years ahead.

Gas Turbine Possibilities

The possibilities of gas turbines for tractors and earthmovers of 300 hp and over should not be passed up lightly. The saving of weight as compared with diesel engines may be of minor concern to the tractor designer. But the reduction of space occupied by the powerplant and its cooling means is always attractive in any portable machine. Inability to use the turbine as a braking means does not handicap the tractor as it may a truck or bus.

The currently high fuel consumption figures reported for turbines may not always be with us as further research develops increased efficiency. Whatever the fuel consumption, the tractor, operating much of the time at a high load factor where efficiency is best, offers advantages over other forms of power use in automotive service. Torque converter characteristics, inherent in the turbine's design, can be used to good advantage in the tractor field. All this warrants careful appraisal, especially as the turbine itself is developed to a higher plane of reliability and better fuel economy.

For operation in dusty fields, considering the enormous amount of excess air used by the turbine, application of turbines to tractors may be faced with the task of developing suitable air cleaners as was necessary when the internal combustion engine was first applied to tractors for farm use (see Fig. 4).

Single-Purpose Machines

Self-propelled, or perhaps better expressed, self-powered farm machines are becoming increasingly popular. These special-purpose machines include combine harvesters, corn pickers, and other harvesting machinery perhaps still to come. A self-propelled "combine" cutting a swath 12 ft wide operated by one man is a warranted investment as compared with a tractor-drawn, pto-operated harvester of 6 ft cut or less, if the operations are on a suitably large scale. With larger farms worked by fewer farmers, more and more operations come into this category where special-purpose equipment is a good investment.

These farm machines are the equivalent of production tools in a manufacturing plant. The manager must decide at what point it becomes more economical to reduce labor cost at the expense of higher investment charges. It's the old story of single-purpose, high-production tools with their high overhead and on the other hand more universal equipment at a lower investment figure but higher labor cost. The trend to date indicates that there

UNI-TRACTOR MOUNTS *ALL* THESE HARVEST UNITS:

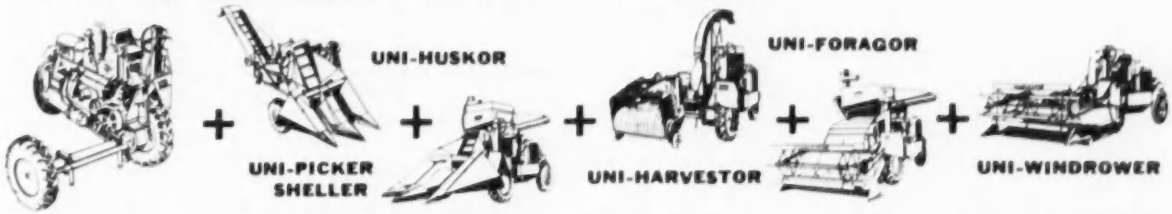


Fig. 5—This unit or carrier tractor—a chassis, to use an automobile term—is provided with a few standardized attachment points for mounting several popular types of harvesting machinery and thus produce in each case a self-propelled farm vehicle. It has many of the advantages of a single-purpose, self-propelled machine and, in addition, offers the farmer a sizable saving in initial cost outlay. A single-chassis purchase serves several mounted machines

will be more special-purpose machinery purchased by farmers rather than less.

Compromise—and the "Tractor Tool"

This leads logically to a compromise position between general-purpose tractors with tractor-operated machines on the one hand, and a complete surender to self-propelled, special-purpose machines on the other. At least one manufacturer has made considerable progress in developing a special-purpose chassis or running gear—a "unit" or "carrier" type tractor—which includes a powerplant and two independent power transmission systems. Upon this one chassis, it is possible to mount suitably designed combine harvesters, forage harvesters, corn pickers, corn picker-shellers, and conceivably many other agricultural tools interchangeable with each other in a resonably short period of time and with little effort. One power transmission system is geared to the driving wheels, the other operates the mounted machinery.

Obviously this compromise provides many of the advantages of both the general-purpose and self-propelled machines. The idea will be of much greater value to the farmer if some industry standards are developed so that there can be some degree of interchange between units of one manufacturer's products with those of another. This may be difficult to accomplish soon, but will likely come about in time.

Hydraulic means for lifting, lowering, and controlling the working depth of both tractor-mounted and tractor-drawn implements overcomes the inconvenience of operators wrestling with long levers located in awkward positions. No tractor is now considered completely equipped without a hydraulic control system. Some standardization as to mounting of pumps on tractors has been accomplished by crawler tractor manufacturers in connection with bulldozers and scrapers. Dimensions for farm-tractor hydraulic cylinders are standardized as an inducement toward greater use and lower cost of this equipment.

An ingenious application of hydraulics to tractors is the coupling of the tractor drawbar or draft element to the control valve of the hydraulic system so that when a predetermined pull is exceeded, a lifting force is applied to the implement which in turn does two things automatically:

1. draft of the implement, and for all practical purposes, working depth of the implement, is maintained constant, and

2. lifting force applied to the implement adds weight to the tractor drive wheels thus making available a considerable increase in traction with a corresponding decrease in wheel slippage.

As the present trend continues of replacing tractor-drawn equipment with tractor-mounted tools, this idea will gain increasing popularity.

Power shifting of heavy tractor drive wheels in and out on their axles for accommodating the tractor to different crop row widths and for requirements of different implements is now in limited use. More general adoption of this feature is predicted for the future.

Farm-tractor engines continue to develop increased horsepower with no corresponding increase in engine displacement or tractor weight, making it possible for one man to accomplish more work in less time. Crawler tractors, on the other hand, continue to run, for performance reasons, slightly more than 7 drawbar hp per ton of weight with no presently available evidence that this ratio will soon be changed materially. Crawler tractors continue to grow in size. The largest tractors in 1930 weighed 21,000 lb, in 1940, 33,000 lb, and in 1950, 42,000 lb. A 1954 model has been recently reported weighing 51,500 lb.

Some attempts have been made to couple two large tractors together side by side, removing the inner sets of tracks. This construction doubles the power and weight of single tractors. The idea, however, has not yet reached the stage of commercial production.

Current and planned construction of levees, dams, freeways and turnpikes is now being handled economically by large earthmoving equipment, including crawler tractors carrying bulldozers and other mounted equipment, motor graders, self-loading scrapers of pull-type and self-propelled design, huge motor trucks, and a long list of other automotive machinery. (See Figs. 6 and 7.) Not only do these efficient earthmovers make it possible to build more modern highways in our well-settled areas, but they also make accessible the regions far removed from present civilization for obtaining their important natural resources. There no longer seem to be any inaccessible places on this earth, nor any job too large for this machinery to handle. However, no limit is seen as to the size and efficiency of these machines to be built in the future. That will depend largely upon the development of proper rubber tire equipment, adequate engine power, and driving components.

Farm Work Animals Disappearing

A quick conclusion as to trends and records to date shows that the motive power of the ages—the oxen, horses, and mules—has all but disappeared from the American scene. The limited numbers still left mainly on small Southern farms are questionably earning their "keep" and will not be with us long.

The two-horse farm teams have been superseded by 40 hp tractors and the big multiple units of two-horse or mule outfits pulling dirt-moving scrapers have long since disappeared in their losing battle with 300 hp self-loading earthmoving outfits.

The internal combustion engine, performing better year after year with the help of the petroleum industry and the steel makers and the addition of rubber tires to the operating equipment, have taken us a long way under the guidance of our automotive engineers.

Predictions . . . Versatility, Comfort

Ahead of us are countless jobs to make work easier for the many who operate our new machines and to eliminate further the large amount of hand labor still required on too many farms. Hand hoeing of cotton and likewise of sugar beets belongs in past history. Hand picking of cotton should be no task

for human beings. Tractors made more versatile and better equipped to do these tedious jobs are certain to appear soon. Special machines are in order where standard tractors and implements are not well adapted to the job at hand.

A "truck driver" may have to be a "husky brute" to stand up under his job; but it is logical enough to insist that a tractor driver be just as comfortable behind the tractor's steering wheel as he is behind the wheel of his automobile. This leads us into torque converters, power steering, hydraulic or air assists on heavy control operations and easy interchange of farm implements on and off tractors between jobs. Too many farm accidents suggest special attention to safety measures.

Specific predictions for the distant future are sure to be hazardous. Let's close by venturing a prediction that the next 20 years will see more progress than we have seen in the past 50 and beyond that express no further opinions.

Earthmovers like these have helped to bring civilization to inaccessible areas.

Fig. 6—The bulldozer, technically a mounted tractor attachment but by popular agreement now including the combined tractor and dozer, is supreme in moving dirt short distances and in general utility on a contractor's job. Here is an ideal crawler tractor application in the industrial field

Fig. 7—An example of long-distance dirt moving for big construction jobs. Here the motor scraper gets an assist from the crawler tractor to facilitate full loading of the bucket, after which the rubber-tired vehicle moves its 20 cu-yd load to the fill at speeds up to 20 mph

Production

MECHANICAL and electronic brains will work their way into machine tools, plant equipment, and factory operations. Yet these mechanical brains will demand more knowledge and intelligence of the engineers who design the products, create the plant equipment and operate the plants of tomorrow. That's the handwriting on the wall for automotive manufacturing in the coming years.

We're at the beginning of a new epoch in manufacturing which will bring to fruition such things as . . .

- **Automated assembly lines.**
- **Machine tools that take directions from a punched tape to fabricate complicated parts without using tooling.**
- **Machines that remove metal by electrical disintegration to form accurate, complex shapes.**
- **A considerable reduction in metal cutting through use of more accurate castings, forgings, stampings, and powder metal parts.**
- **Electronic machines that plan, schedule, and control production with a fraction of the time and manpower needed today.**
- **A production engineering-metallurgy-design engineering triangle more closely integrated, and made up of men with broader backgrounds in the basic, applied, and management sciences.**

These are probably only a few of the things which will give a "new look" to the automotive plant of the future. One prominent manufacturing executive of the automobile industry expects that in the next 10 to 15 years new automotive plants will have to be built to provide one-half again as much floor space as is available today; these new plants will be necessary to suitably house modern manufacturing facilities and to keep step with the increased demand for automotive transportation.

We can't possibly predict fully how the production engineer will equip and manage these new plants. Nor can we completely forecast how he will cope with continuing cost reduction demands by using new methods, new materials, new designs, new devices, new controls, and new energy forms. But we can get a glimpse of likely developments in the next decade by examining present trends in automotive and aircraft manufacture.

Engineering ... *A Forecast*

by E. F. Gibian

1. Automation:

An Engineer's Dream Becomes Reality

In manufacturing trend discussions, automation hogs the limelight because of its impact on cost, quality, design, and machine tool developments. Although it's a household word, "automation" has yet to be defined. To some it means almost complete mechanization of the production line. To others it's equipping a single machine tool so as to perform automatically a series of operations.

Let's take a look at the automation of the production line. It includes automatic transfer or conveying of workpiece from operation to operation; the central control of all operation steps; and automatic loading and unloading. Actually, that's the kind of automation achieved by the automotive and aircraft industry using transfer machines introduced in the early 1940's. It has been perfected by improvements in automatic material handling devices. Sometimes these devices tied in a series of transfer machines to a plant-wide operating unit.

This type of automation will be widely used where both large volume and product design stability will warrant the large investment. But production engineers will have to work closely with design engineers to come up with designs suited to cost-saving automation. Assembly operations are a particularly fertile field. They are still largely performed by individuals on conveyor-controlled assembly lines. Already a reality is a partially automated assembly line in one aircraft engine plant.

The second type of automation deals with single machine tools, equipped with automatic control mechanisms, to perform a series or sequence of operations. Particularly interesting are director-controlled machine tools. Applying electronic programming and numerically controlled devices should make it possible to program very complex operations to almost any precision. And all this can be done *without* masters, templates, patterns, and similar difficult and expensive tooling.

An outstanding example of this machine tool type of the future is M.I.T.'s director-controlled milling machine.

There's work ahead before these machines find their rightful place in the modern production picture. They'll have to be improved and refined. And engineers will have to learn how and where to use these machines. Relatively complex parts, pro-

SAE Golden Anniversary Author

E. F. Gibian

E. F. Gibian is chief industrial engineer for Thompson Products, Inc. Since July, 1933 he has served with Thompson in the positions of master mechanic, chief engineer of the Tapco plant, factory manager of the jet division, and chief industrial engineer, respectively.

Gibian played a key role in the planning and early operations of the large Tapco plant. He was responsible for formulating manufacturing and inspection methods, specifying equipment, and developing new processes. Under his direction advanced methods in the production of valves, turbine blades, and other components were put into practice.

Born in Domazlice, Czechoslovakia in 1894, Gibian attended the Czech Polytechnic Institute at Prague and received a degree in mechanical engineering in 1921. After graduation he was employed by the Skoda Works of Pilsen as designer of mining machinery and materials handling equipment. He moved then to Columbus, Ohio in 1923 and took a position as development engineer with the Jeffrey Mfg. Co. From 1925 to 1933 he was chief engineer for Vichek Tool Co. of Cleveland.

Gibian became a member of SAE in 1928. Since 1946 he has worked on the Production Activity Committee, serving as its meetings vice-chairman in 1950. He was elected vice-president representing Production Activity in 1952. In the past few years he has served on many SAE Production Forum panels, and has presented papers on production methods, marterials handling, management controls, and statistical quality control.

He has also held active membership in organizations such as the American Ordnance Association, American Society for Quality Control, the Manufacturing Methods Committee of the Aircraft Industries Association, the American Society for Metals, and the Cleveland Chamber of Commerce.

duced in small and medium volume, offer a fruitful field. That's because a fully automated production line isn't economically feasible in these applications.

One aircraft engine accessories manufacturer recently completed an intensive study of director-controlled machine tools for producing intricate parts with irregular surfaces. These parts now are being machined using duplicating equipment and extremely complicated masters. It takes about six months to tool up for a new design. The reluctance to retool because of this lengthy time cycle and high cost is likely to freeze a slightly imperfect design.

A director-controlled machine tool needs no cams, templates, masters. The entire "tooling" consists of the punched paper tape. The accessories manufacturer found that a director-controlled machine will shrink both tooling time (from six months to three weeks) and tooling cost. Design changes and improvements will present no tooling problems. That's because a portion of the programming tape can be cut out and replaced by a revised strip.

Furthermore, the director-controlled machine will be used not only for making samples and small production lots; it also can be used to make quickly accurate steel masters for duplicating equipment of the high production lines.

This example illustrates the coming impact of director-controlled machine tools on design, production planning, tooling, quality control, and inventory control. It also points up the shift of skill from the toolmaker and tool designer to the engineer who programs and prepares the director command medium . . . be it a deck of punched cards, punched tape, magnetic tape, or a photographic film.

2. Manufacturing Processes:

Rife with New Twists in Shaping Metals

We can't too readily speculate on the effect of new manufacturing processes on the future of production engineering. But we can examine the probable effect of: (1) several new processes which have progressed beyond the laboratory stage and are ready for wider applications, and (2) improvements on long-standing processes whose usefulness has been greatly enhanced by recent innovations.

• *Electro Machining*

Also referred to as "electric-arc machining," this process removes metal by the action of electrical discharges between an electrode acting as a tool and the workpiece. There is no actual contact between the tool and the piece worked on. So the tool may be a soft, easily machinable metal such as brass.

The process was originally developed for producing regularly and irregularly shaped holes in hard metals, shapes difficult to produce by conventional machining methods.

What makes the process so interesting for the future is its rapid expansion into new fields by modifications of the machine and electrode arrangement. Here are just two examples: First, die cavities may be produced by this process. Second, surface grinding may be performed using a revolving brass wheel as an electrode. This second application offers much promise for economic, accurate machining of form tools, milling cutters, jet engine blade roots, and other relatively complicated shapes.

• *Ultrasonic Machining*

This process overlaps somewhat electro machining in its applications. For the present, however, the process will probably continue to have a narrower field. That's because it is essentially a tool room process for manufacturing intricate female die shapes of high precision and finish. It is a relatively slow process. But it's typical of new processes having special applications with which the future manufacturing engineer will have to be familiar.

• *Foundry Processes*

The desire to produce castings to finished or nearly finished size had led to refinements of existing processes rather than to inventions of entirely new methods. The results of these innovations are startling nevertheless.

Shellmold castings will eventually replace ordinary sand castings in high-production small and medium weight parts. The reason: their economy, good finish, dimensional accuracy, and the adaptability of the shellmold process to complete mechanization.

Investment casting has gained impetus from the aircraft industry's demand for intricate castings made from high alloy materials. Most significant innovation is the frozen mercury pattern. It will make possible extension of investment casting to larger sizes and more complicated shapes, including intricate hollow shapes of unusual dimensional accuracy and excellent, smooth finish.

• *Powder Metallurgy*

Just like foundry processes, this manufacturing area is undergoing innovations and refinements opening up entirely new applications. Heat-treatable, copper-infiltrated powdered metal compounds will permit manufacture of wearing parts with properties of hardened steel parts produced by costlier machining.

• *Forging and Metal Forming*

Advances here will also contribute to considerable cost savings and quality improvements. Modern forging presses, combined with forging rolls and other auxiliary equipment, such as electric gathering machines, have proved their value in producing precision forgings of uniform quality with minimum waste. The adaptability of the impacter forging process to automobile industry needs is still somewhat uncertain. Insufficient experience has been accumulated to make it the basis for predictions . . . so much more reason for the automotive production engineer to watch the impacter development very closely.

Other novel metal forming processes may become significant in the next 10 years. For example, Lodge & Shipley's "Flo-Turn" process has attracted great interest in the aircraft engine industry. This novel forming method transforms metal discs into conical rings of complex contours and varying wall thicknesses by displacing the material in one operation without stretching. Such shapes heretofore have been produced in a succession of deep draws and intermediate anneals, with less accuracy, at higher cost, and at greater wastage of material. Hot extrusion of steel, until recently confined to relatively small parts such as valves, has been extended to much larger forgings such as aircraft propeller blades.

It is interesting to note that the old art of stamping, aided by the advent of mechanized cold forming and welding methods, is staging a comeback in many areas of automotive and aircraft engine design. Stampings lower costs without sacrificing quality for parts such as rocker arms, tappets, various chassis brackets, and some jet engine blades and vanes.

Please Turn Page

3. Electronics:

The Nervous System of Tomorrow's Factory

The influence of electronics has already been touched upon in discussing director-controlled machine tools. But when you consider the future role of electronics in the entire broad field of controls in general, the anticipated results are truly staggering.

• *Value of Electronic Controls*

We are all familiar with the value of the electronic controls installed as standard equipment on some of our machine tools and in our automated lines. We know the marvelous functions performed by electronically controlled equipment in civilian and military airplanes, guided missiles, and in some industrial processes. In our plants we already take for granted electronic tabulating machines that produce inventory records, figure the payroll and write out the payroll checks. Our design and development engineers use analog and digital computers for solving complex problems with uncanny accuracy and unbelievable speed. Closed circuit industrial television and radio communication systems for controlling material movements and testing facilities will surely become quite commonplace.

• *Electronically Controlled Planning and Scheduling*

One of the most intriguing developments lies in the possibility of having electronically controlled machines take over the mechanical functions of the planning and scheduling processes of an entire plant. As of today it is feasible, although not yet necessarily practical. Here is how it would work. An automobile manufacturer would receive all car orders from dealers or distributors by wire in punched tape form containing data as to model, color scheme, tires, accessories, and other features. These documents, in the form of punched tape, can then be consolidated and processed through decoding and tabulating machines, computers, and tape-controlled typewriters. They would compute the most economical production schedule, maintain the required inventory, automatically direct the flow of components to the assembly lines, issue shipping orders, and produce correct invoices.

So not only the mechanical functions of machine tools and equipment may be better performed with the aid of electronic controls; but the administrative and managerial plant tasks will be speeded up and improved by the introduction of electronic devices.

4. Human Element:

Industrial Wonders Demand More Knowledgeable Men

All these advances and improvements are brought about by human intellect and human thinking. While the popular belief may be that an electronic computer is a thinking machine and replaces the human brain, the very opposite occurs. Higher intelligence is required to make use of such a device. Install an automatic pilot in a plane and you expect more intelligence from the human pilot for whose convenience the electronic device has been installed.

A similar effect has been brought about by improvements in our industry. Install an automated line and immediately you need better tool engineers, more intelligent production control men, higher skilled cost accountants, more versatile machine maintenance men, to name a few links in the chain.

The sweeping changes in manufacturing technology which are expected in the next decade will be only as successful as we shall be able to support them by human beings properly trained for using and servicing these wonderful tools put at industry's disposal.

No plant can expect to derive a lasting benefit from automated lines, director-controlled machine tools, computers, and similar devices, unless it will be staffed by manufacturing engineers who possess adequate knowledge of physics, electronics, higher mathematics, chemistry, metallurgy, and allied sciences.

Production engineers operating vastly more complex plants, and engineers on their staff, need to be familiar with statistical techniques, operations research methods, linear programming, and other mathematical aids.

• *Approaching The "Automatic Factory"*

The closer we approach the state of the "automatic factory," the greater becomes the interdependence of the various branches of the manufacturing organization and the need for constant communi-

cation and transmittal of information. Design engineers, metallurgists, and production engineers will exert mutual influence and need even closer liaison. The greater the role of automation and control of machine tools, the more pronounced the shift of skills previously mentioned.

• *Direct versus Indirect Labor*

The distinction between so-called direct and indirect labor may become quite hazy, if not meaningless. Old concepts of cost accounting dealing with direct labor dollars and overhead rates will finally be inadequate for controlling or computing manufacturing costs. Here again production engineers and cost accountants will have to establish an entirely new type of closer relationship to cope with the changing aspects of industrial management in the age of automation and electronics.

I have attempted to extrapolate current knowledge to predict what is going to happen in the future. The automotive industry already has demonstrated that its management and its engineers have the understanding, vision, and courage to pioneer in manufacturing ideas and scientific developments. Any errors in this forecast are therefore likely to be on the conservative side.

Background for Tomorrow's Production

When the automotive industry introduced the productivity increase clause in its 1948 labor contracts, it declared its faith in the future of production engineering. It was also a forceful reminder that increased productivity stems chiefly from technological improvements. And the responsibility for these improvements rests with industry's management, particularly its production engineers.

Wage earners as a group cannot increase their **real** earnings much faster than the overall rise in the nation's productivity. This fact was documented in the 1953 survey on U. S. employment and wages sponsored by the Twentieth Century Fund. The survey predicts that over the next decade or two the buying power in the pay envelope can be upped an average of 2.5 to 3% a year. But it also finds that **real** wages are **four** times higher than a century ago.

What makes it possible for our engineers to maintain that ever-increasing rise in productivity? Can we expect a continuing rise in the next decade or two? These are some of the things one may ask in looking into the future of production engineering.

Professor Sumner H. Slichter, in examining "Why Is U. S. Industry So Productive?", cites five political, sociological, and economic factors as an answer:

1. Security of person and property.
2. Lack of social stratification.
3. Rapid growth of population.
4. The large middle class in the U. S.
5. U. S. industry is largely in the hands of men who desire to make money rather than enjoy wealth.

The first two factors grow out of our American system of government. The third and fourth factors result from our economic situation. But the fifth factor is of greatest interest because it is an essential result of the American free enterprise concept.

Men who desire "to make money" rather than "enjoy wealth" are putting capital to work and making possible technological advances. These advances create the steady growth in productivity with its accompanying rise in the standard of living.

There is no reason for any of the five factors to lessen their influence on industrial developments for the next decade or two. Add to this the many recent technological developments that will enhance the willingness to plow back earnings. So we may safely predict that we're on the threshold of major changes in production techniques.

What's Ahead in Engineering

WHO knows what magic the metallurgy of tomorrow will bring, muses author Riegel in this Golden Anniversary article. Taking off on the basis of current materials use, development, and research, he feels the foreseeable future will bring . . .

• Continued extensive use of iron and steel—with increased use of alloys, overlays, and sandwich materials to impart special characteristics.

• Expanded usage of light metals such as aluminum, magnesium, and titanium.

• Plastics—by themselves and in combination with metals—which will pre-empt applications that now rely on metals.

• Still-to-be explored alloying elements, a pinch of which will greatly enhance properties of metals.

• More effective use of metals through broader knowledge of how to make stresses act to the benefit, instead of to the detriment, of a part.

Materials

by G. C. Riegel

1. Through a Rear-View Mirror

One of the lessons that the keenly observing Daniel Boone learned from the American Indians was their cunning sense of direction in the wilderness. When an Indian went into an unexplored region, he not only "blazed" a trail but periodically reversed his gaze to see how the details of the scenery looked as if he were back-tracking. Familiarity with what is past and the ground overcome gives us a sense of safety in probing the unknown future into which our successors must travel.

On the 50th Anniversary of our Society of Automotive Engineers, it would be interesting to look back to the date of its origin to see what were the prevailing types and the changes which have since been made in engineering materials. Such a reversed view may enable us better to envision what to expect in the next half-century and beyond.

In 1905, most of the roadway bridges and railroad trestles were wooden and over them wooden vehicles carried the articles of trade. Today the old covered wooden bridge is almost as rare as the tassel-topped wooden surrey. Wood has almost disappeared in automotive construction as have the wooden wagon and buggy factories.

Back in those days, when about 60% of the nation's population earned its livelihood in agriculture, the young rural swain, even below voting age, wanted to have his own horse and buggy for dating his best girl . . . just as our young men of today and of many tomorrows will crave their private vehicles for that never-outmoded reason.

In the year 1905, there was one passenger car for every 1080 persons; 50 years later there is a passenger car for every 3.2 persons in the United States. (See Fig. 1.) Or, to say it another way, all of the

SAE Golden Anniversary Author

G. C. Riegel

G. C. Riegel is chief metallurgist with Caterpillar Tractor Co. in Peoria, Ill. He has been associated with Caterpillar since 1926, when he was employed as plant production metallurgist.

Riegel was born in Knox County, Mo., in 1892 and is an alumnus of Central College, Fayette, Mo., having received his bachelor of arts degree in 1914. After working two years as a chemist in the South Works laboratories of Illinois Steel Co., he did graduate work at the University of Chicago.

From 1918 until 1923 he was associated with Mitchell Motors Co. in Racine Wis., advancing from the position of chemist to that of chief metallurgist. He then moved to the Gehrlinger Steel Castings Co. of Milwaukee, Wis. and served with them until 1926, when he joined Caterpillar Tractor as production metallurgist.

Riegel has been a member of the Handbook Committee and Publications Committee of the American Society for Metals and has also served on the Handbook Committee of the American Welding Society. In past years he has also been a committee member for conservation of strategic alloys on the National Metallurgical Advisory board.

He has been the author of many technical papers presented before meetings of SAE, the American Society for Metals, and the American Society for Testing Materials. He has also secured a number of patents as the result of his research.

He has taken an active interest in many SAE activities, serving as a member of the Iron and Steel Technical Committee for many years and as its chairman in 1946–1947. He was SAE vice-president for Engineering Materials Activity in 1953.

Fig. 1—In 1950 there was one passenger car for every 1080 persons in this country. Today there's a car for every 3.2 persons

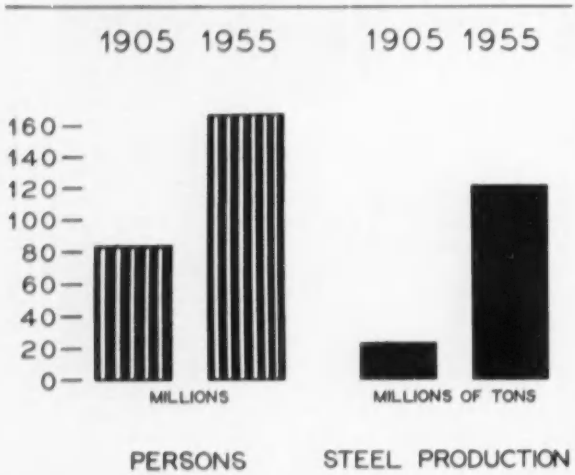


Fig. 2—In the 50 years since 1905 steel output has increased six-fold and our population has been doubled

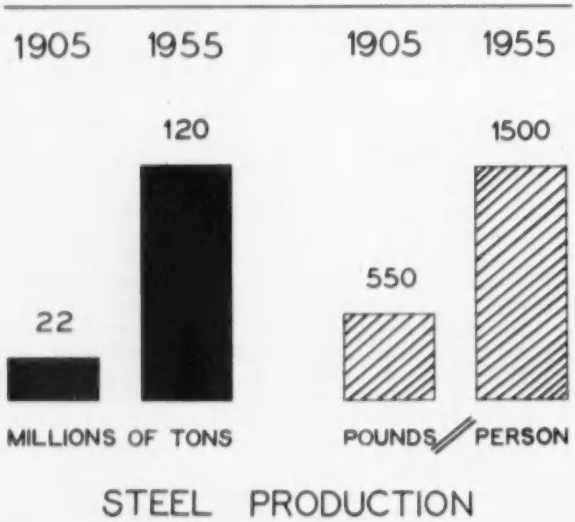


Fig. 3—Since 1905 the per capita production of steel has jumped from 550 lb to 1500 lb

people of the United States plus those of Great Britain (50,368,454—1951 census) could be put in the American passenger cars at one time, comfortably.

While the negative feature of the law of Malthus can easily be disproved ("overpopulation will always be held in check by war, pestilence, and famine"), the positive implication is a fascinating and inviting challenge. Can engineering materals keep pace with, or exceed, the pressure of increasing population? When we talk of exhaustion of our rich iron ore deposits in this country and hear the annual census recorder chalk up 4,000,000 new souls (a net gain of 2,500,000 in one year), we see the bold outline of the task ahead.

Looking back again at this nation when it was first settled with its untouched virgin resources, there dwelt here possibly 6,000,000 Indians, restless under the dread of extinction or starvation. Today 165,000,000 people with vastly depleted natural resources continue to enjoy the highest standard of living among the 2,400,000,000 people of the world. Can we maintain our pace and our place?

2. *Looking Forward*

When our rich iron ore is gone and we can't afford to import it, from what source can we derive our increasing per capita rate of steel consumption?

Fig. 2 compares the steel production and population of 1905 with that of 1955. In 1905 when our population was approximately 83,000,000 (actual—83,594,000) we produced 22,000,000 tons or 550 pounds of steel per person; whereas with 165,000,000—double the 1905 population—we produced 120,000,000 tons—or almost three times as much per person—1500 lb. (See Fig. 3.)

Thus while the population was doubled, our steel consumption reached six-fold. If our population gains 120,000,000 in the next 50 years, will our steel consumption reach ten-fold? This looks fantastic—1,240,000,000 tons of steel produced annually? Yet when we compare the rate of increase of production of some of the nonferrous metals, which amount to but 1% or so of steel production, these rates are also fantastic. (See Fig. 4.) For example, aluminum has not jumped a mere six times (600%) in fifty years, but 90 times (to 9,000%). To quote the percentage increase of titanium since it started as a metal of commerce a few years ago would be almost astronomical . . . three tons in 1948 to 13,200 tons in 1955 (440,000%).

These newer metals, however, bring with them not only a bid for replacing some steel, but also the hope of satisfying the expanding consumption of a metal-hungry civilization. Already the aluminum bridge is less of a curiosity than the covered wooden bridge. Aluminum skyscrapers, with interior steel reinforcement, Fig. 5, are practical structures.

While the economics justify importing rich iron and aluminum ores, who can say that the iron-red clay (iron-aluminum silicate) of Alabama and Georgia can't furnish both iron and aluminum on a grand scale . . . like the lean copper mountains in Arizona that are chiseled away for 1% copper and smaller percentages of other metals, notably molybdenum? As far as iron is concerned, there are many *intermediate* steps, such as high silicon (the taco-

nites) and high sulfur ores, that can be profitably exploited *here* before leaner ores are considered.

3. *Stretching Our Resources*

While we are expanding consumption, conservation can also extend greatly the use of the existing supply. Some valuable experiences in stretching our resources were gained when our economy was "run through the wringer" of three recent wars. For example, 0.001% of effective boron could replace as much as 1.5% of nickel and 0.5% of chromium in promoting the hardening quality of an alloy steel. (See Fig. 6.) Most nickel and chromium are imported. Our known supplies are very meager.

Another method of conservation which has never been stressed to the point of enforcement is that of the irrecoverable loss of steel from rusting. Every time an automobile body containing 1000 to 1500 lb of steel is allowed to rust out in the used parts "grave-yard" or scrap yard, that quantity of iron rust is dissipated in its surroundings or lost in the open hearth slag when the scrap is recycled.

In the April, 1935, issue of the *SAE Journal*, 20 years ago, the following statements were made by F. P. Gilligan[1], under the caption "New SAE Steel Data Embody Wide Engineering Significance":

"In 1905 a group of automotive engineers known as the Mechanical Branch of the Association of Licensed Automobile Manufacturers devised the first chemical specifications for automotive steels.

"The SAE Iron and Steel Division published its first report in 1911.

"In 1912 the SAE numbering system for steels was adopted.

"In 1915 the first physical properties charts for SAE steels were published.

"SAE was the prime mover in the adoption of grain size control.

[1] *SAE Journal*, April, 1935, p. 13—"New SAE Steel Data Embody Wide Engineering Significance" by F. P. Gilligan.

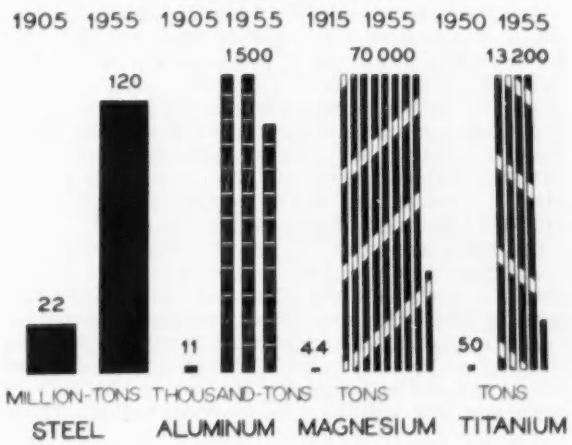


Fig. 4—Nonferrous metals—such as aluminum, magnesium, and titanium—have a fantastic increase in production compared with steel

Fig. 5—The covered wooden bridge of yesteryear is more of an oddity today than the modern aluminum structure, such as this skyscraper

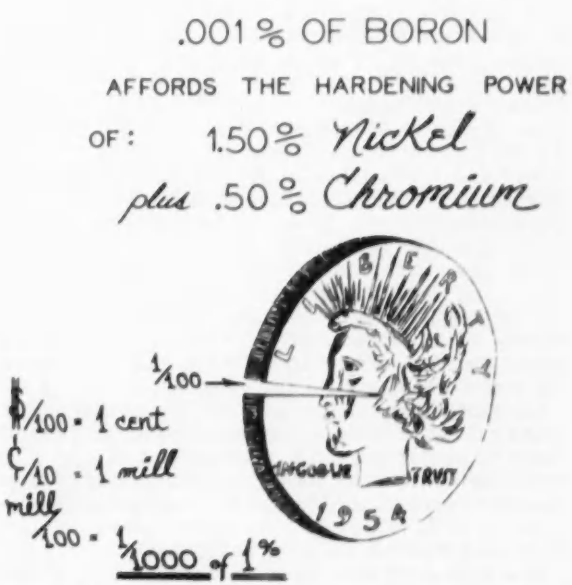


Fig. 6—Just a pinch of boron, 0.001%, imparts to alloy steel the same amount of hardening ability as 1.5% nickel and 0.5% chromium

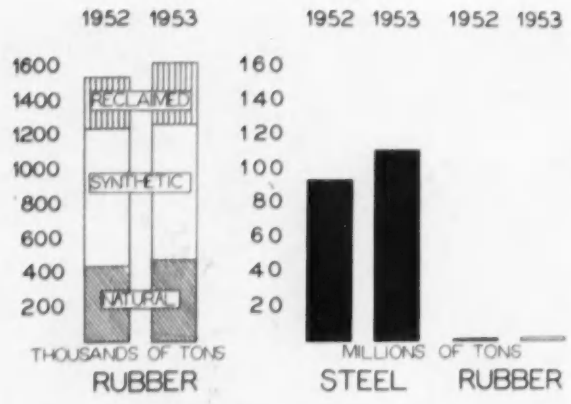


Fig. 7—Output of rubber compared with that of steel

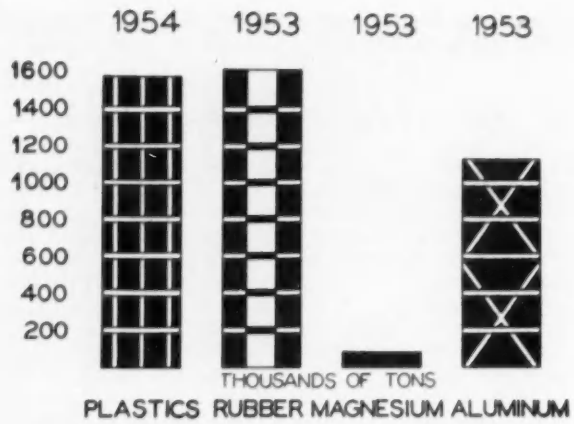


Fig. 8—Comparison of the outputs of elastomers and light metals

"SAE also was continually policing the types of composition in order to minimize the number of variants which were creeping in, but which had no significance with respect to comparative physical properties obtained by heat treatment, and therefore were uneconomical."

Non-Metals

A more recent competitor of metals, a man-made material, has stuck his nose in the door and may wedge his way in further, namely, plentiful plastic. The elastomers have been known and used in a limited field ever since Goodyear accidentally dropped his rubber-sulfur mixture on the hot cook stove some 115 years ago. It would be difficult to imagine where the automobile industry would have been without abundant rubber. "Abundance," however, was only guaranteed by man's synthesis of a family of elastomers equal to and better than the natural rubber. Everyone knows how much better a buna-S innner tube holds air than the natural rubber. See Fig. 7 comparing rubber output with that of steel.

It should be noted in passing that more glass was used in automobiles last year than in all the residences built in the same period.[2]

Far and beyond the knob and handle usage of plastics in the modern automobile is the advent of the all-plastic body. Here real tonnages are finding their way into production of sport cars, pleasure boats, and aircraft interiors. Furthermore, the silk worm, the woolly animals and their hides are losing the competitive race for the interior decorative fabrics of automotive craft. Cellular plastics are replacing steel springs in cushions and balsa wood for water buoyancy in life-saver constructions.

Paradoxical as it may seem, large segments of our principal metal industry are engaged in, or making plans to supplement, the manufacture of iron and steel pipe with plastic pipe. Plastic pipe has already gained an acceptance that means tonnage in the future. A 20-ft section of 3-in. pipe of plastic weighs 13 lb as compared with 153 lb for steel.

It is estimated that there were produced 1,575,000 tons of plastic resins in 1954. This is 325,000 tons more than the total production of aluminum in 1953. Fig. 8 compares production of elastomers with that of light metals.

One of the major difficulties in substituting one metal or material for another is the problem of equivalent strength and stiffness. For example, steel with an elastic modulus of about 30,000,000 compares with aluminum at about 10,000,000.

Since, however, the comparative weights are of the same order, as shown in Fig. 9, it would take 3 analogous sq in. of aluminum of the same section to be the equal of 1 sq in. of steel in tension or compression. Magnesium is about two-thirds the weight of aluminum; but again the elastic modulus of magnesium is about two-thirds that of aluminum. Hence, it would take 1.5 sq in. of magnesium (or equal weight) to be equal to 1 sq in. of aluminum in strength.

As can be seen from these comparative data, nature has not made it easy to surmount this obstacle, but by skillful arrangement in shape, rigidity of section has been achieved by mechanical engineers while saving weight. (See Fig. 10.)

Layer, Cored, and Sandwich Construction

In another manner, engineers have moved around part of these obstacles by making composite sections. For example, the steel-cored aluminum wire for electrical transmission has pre-empted the field formerly held exclusively by copper. Others of the sandwich and clad-metals are bound to take on the advantages of one set of properties without sacrificing too much of lightness, corrosion protection, and thermal conductivity. The housewife recognizes the advantage of the copper-clad or aluminum-clad stainless steel cooking utensil.

Sandwich construction may contemplate plastic filler inside a metal shell, or metal inside a plastic shell . . . such as steel, aluminum, and magnesium pipe, having inside and outside of plastic coated.

Plastic coating of metals has already reached the stage of continuous manufacture. Some of the very tough and stable resins are applied on the coils of sheet and strip steel as they are being reeled. These

[2] *Automotive Industries*, June 15, 1954—p. 168.

resins are so adherent that sheering and limited cold forming does not separate the bond. The extent to which such plastics will stretch our supply of metals is unpredictable.

Beyond these methods of escaping the bounds of nature, the sintered metal compacts are stepping into the picture, and offering new and useful properties. For example, aluminum oxide bonded with metallic aluminum has higher strength and higher temperature resistance in the range of 400 to 600 F than any solid solution alloy of aluminum. Most of the aluminum piston alloys suffer drastic strength losses when heated continuously at 450 F and higher. The new sintered product may greatly extend the usefulness of aluminum alloys in the higher temperature applications. The sintered aluminum-iron magnets have given promise of replacing the scarce alloy magnets containing cobalt and chromium.[3]

Another new magnetic material which has high cohesive force, and is made without the use of strategic metals, is being produced under the name "Indox." It is made of iron oxide and barium carbonate, is lighter than metal and is a nonconductor. A similar magnetic material, made under the trade name "Magnadur" is composed of iron oxide and barium. In addition to its high cohesive force it also has high resistance to demagnetization.[4]

The sintered metal carbide cutting bits have so increased the rate of metal removal that our old friend "high-speed steel" has become slow-speed steel. In this revolutionary change in machining practice, a fraction of an ounce of strategic tungsten as "carbide" replaces pounds of metallic tungsten in high-speed steel.

Minute Alloy Content Potent Metal Saver

Mention has already been made of the saving which a few thousandths of one percent of boron could effect in our constructional alloy steels. It has been reported that during the Korean War as much as 1,500,000 tons[5] of alloy steel were made using boron by which some 30,000 tons of scarce alloys—18,000 tons of nickel, 9,000 tons of chromium, and 3,000 tons of molybdenum—were saved. (See Fig. 11.)

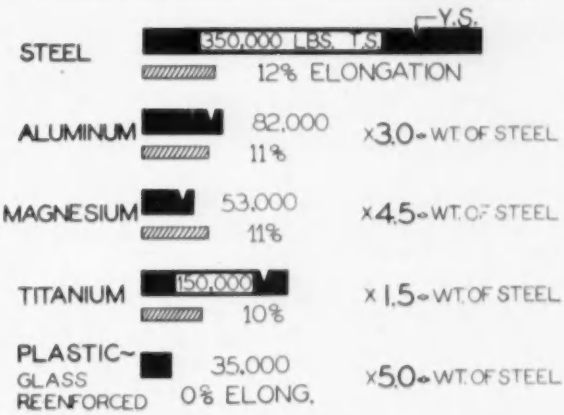


Fig. 9—Comparative strengths and weights of engineering materials

Use of "H" Steels Another Economy

In 1948, SAE in cooperation with AISI, sponsored the production and use of steels on the basis of standard hardenability bands, the so-called "H" steels. One of the primary concepts of this new departure was the more effective use of the recycled alloy present in the melt and lessening the required amount of alloy additions to meet the specifications. For example, when a preliminary melt test showed that one-third of 1% of nickel was present, it was only necessary to add sufficient new metallic nickel to bring the content to approximately 0.5% in order to fulfill the standard range of composition. The same general principle of conservation applied to molybdenum, and in a degree to chromium.

It is noteworthy that a year after the "H" band steels were adopted, about 6% of the total alloy steel output was made on this basis. By 1953,

[3] "Annual Materials Engineering Review and Forecast," by T. C. DuMond, p. 111 in *Materials & Methods*, January, 1954.

[4] *Ordnance*, March-April, 1954—p. 792.

[5] Porter Wray (private communication).

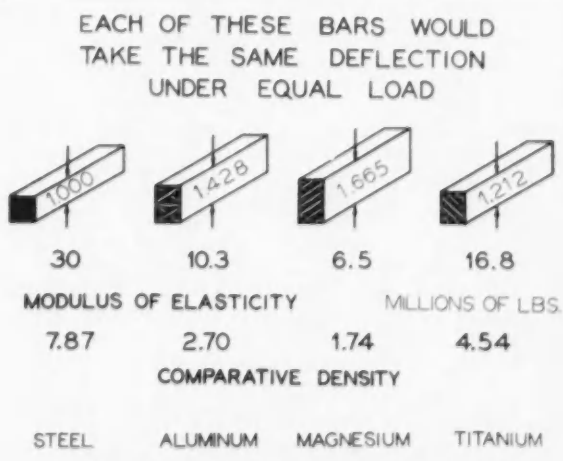


Fig. 10—Elastic modulus and density of metals compared

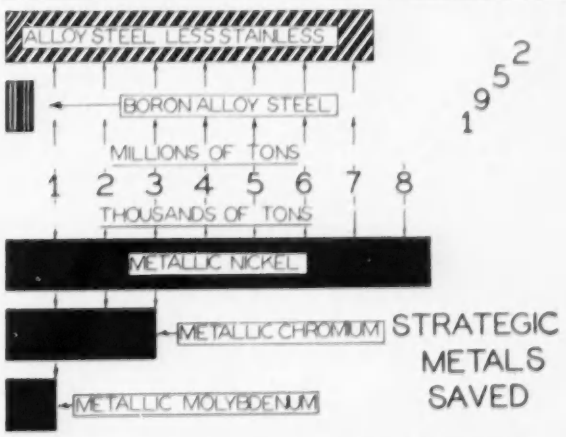


Fig. 11—In 1952, use of boron in alloy steel saved thousands of tons of metallic nickel, chromium, and molybdenum

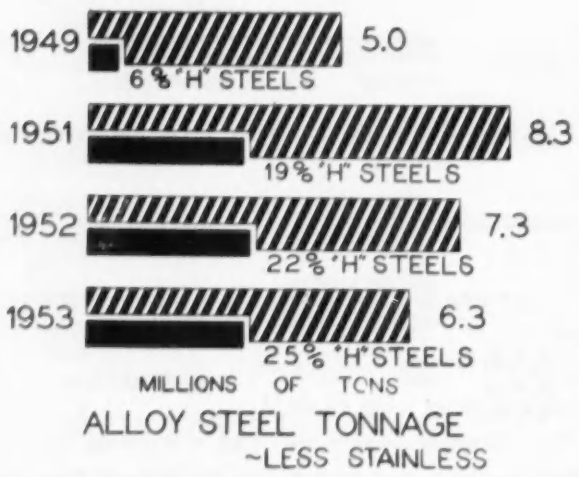


Fig. 12—By 1953, just a few years after they had been introduced, "H"-band steels represented 25% of total alloy steel output

when alloy steel production was 6,300,000 tons, 25% of the alloy steel was being made on "H" band specifications. Fig. 12 shows the growth in "H" steels. This is a notable achievement in conservation.

The use of the rare earths such as cerium, lanthanum, neodymium, praseodymium, and samarium in quantities as small as 0.1% are reported to have conveyed useful benefits upon the transverse properties of armor plate, making the ballistic and notch sensitivity behavior unusually good at minus 40 F. This practice as reported by Lillieqvist and Mickelson shows that as much as 3% of scarce nickel could be replaced in armor plate and attain equivalent performance from the tests made in laboratories and on proving grounds.[6]

It has also been stated that with such additions to the plain low carbon steels the beneficial effects of such alloying advantages are economically justified for the improvement of surface qualities and reduction in conditioning costs. The alloy appears to increase the fluidity and thus affords lower pouring temperatures.

Some of the same alloys in similar minute amounts are used to improve the hot-working characteristics of the heat-resisting alloys, which break up in hot rolling or hot heading. Dr. C. B. Post and associates illustrated the difference in the behavior of the hot-working characteristics of high nickel-chromium, heat-resisting alloys. They showed that, with about 0.04 to 0.08% of the rare earth metals added to the alloy composition, hot rolling and hot upsetting could be performed with comparative ease. In some instances the alloy was incapable of being hot upset unless the rare earths were added.[7]

Molten cast iron has been treated with a few hundredths of a percent of these rare earth metals, cerium, principally, and with the more abundant magnesium in about the same ratio, with the surprising result of making a normally brittle cast iron *ductile*. Here again new uses for an ancient metal which formerly resisted hot working, and welding, are being advanced into the competing family of alloys of iron.

It is surprising what a very small amount of an alloying element will do in elevating the recrystallization temperature of a pure metal. The added element or elements are effective whether in solid solution or undissolved. There are many compositions of alloys which are yet to be explored. Some of the most common of our metals are beginning to be prepared for services formerly performed only by the relatively scarce materials such as nickel, chromium, cobalt, and molybdenum.

For example, the National Ordnance Laboratory at White Oak, Maryland, has brought out an alloy of iron and aluminum to which are added small amounts of vanadium and molybdenum called "Thermanol."[8] It is stated to have 50% higher electrical resistivity than the common nickel-chromium alloy and is 23% lighter than stainless steel. It has heat and corrosion resistance equal to stainless. It should cost measurably less.

Not only are the effects of these certain small amounts of alloy useful in the field of ferrous metallurgy, but the nonferrous can match the importance of property modification by minute additions—such as beryllium in copper, calcium in lead, cerium in magnesium, chromium in titanium, titanium in aluminum.[9]

The addition of tantalum to titanium for elevating its recrystallization temperature might be explored.

Metal Purity

Another striking example of the effect on the properties of metals by the removal of impurities is this statement by C. G. Suits: "Pure iron crystals, 100 times stronger than any known metallic crystal, have been developed by the General Electric Co. The crystals have a tensile strength of nearly 1,000,000 psi."[10] While this is in the stage of a laboratory curiosity, it points to the answer which has long been asked: "Why is common steel comparatively so weak?" This pure iron approaches the theoretical cohesive strength.

As little as two millionths of 1% of impurity in germanium makes it useless for a transistor while one millionth is tolerable. Such limits for impurities or minute alloys have already outstripped the spectrograph, even as the latter exceeded the analytical accuracy of wet analyses. It has been stated by Dr. E. R. Gaerttner[11] that an electronic neutron spectrometer for chemical analysis may go as far beyond the light emission spectroscope as the electron microscope surpasses the ordinary microscope.

With new and extended micro-perceptive devices in the hands of our technicians, we may discern what are the nuclear forces and arrangements which seem so baffling to our generation. As an illustration, we might ask what makes a few millionths of

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[6] AIMME Transactions, December, 1952, G. A. Lillieqvist and C. G. Mickelson.

[7] *Journal of Metals*, November, 1951, p. 973—"Hot-Workability of Stainless Steel Improved by Adding Cerium and Lanthanum." C. B. Post, D. G. Schoffstall, and H. O. Beaver.

[8] *Ordnance*, March-April, 1954.

[9] Micrometallurgy—The Metallurgy of Minute Additions, "ASTM Proceedings 1953", by Jerome Strauss.

[10] *Journal of Metals*, April, 1954.

[11] *General Electric Review*, March, 1954.

fluoride, added to a city's drinking water for lessening decay in youngsters' teeth, render artificial ice so fragile that it is commercially intolerable.

Quoting Dr. L. P. Lessing on "Pure Metals",[12] "Since man's history has been written in terms of metals, this foreshadows a new metallurgical age.

"The Bronze Age gave way to the Iron Age as man began to refine and separate his metals. The Industrial Revolution came about when men suddenly learned to remove the impurities from the iron. This ushered in the Steel Age.

"Even more recently, the wresting of the more elusive metals, aluminum and magnesium, from their ores, has opened the door to the Light Metal Age. The purifying of zinc by fractional distillation brought it into wide usage as a structural material among the light metals.

"The needs of atomic industry and its thermonuclear reactions, together with the new order of temperatures encountered by supersonic aircraft, have put a new premium on high purity metals. Among these are molybdenum, titanium, zirconium, hafnium, beryllium, and the derivatives of uranium.

"Orientation of the crystalline faces of pure metals reveals unusual properties. One face of a copper crystal corrodes five times faster at 400 F than another face. One face of a nickel crystal promotes catalytic reaction 1000 times faster than another face. One face of a pure metal suffers wear loss much more rapidly than another face."

It is indicated that, with high purity metal and proper orientation of the crystalline faces, an unexplored range of strength and properties is available to us from the metals we now use. It may be as the Bell Laboratories have found that the metal must first be made pure and then properly alloyed with minute amounts of other metals or elements to produce the desired properties . . . for example, the alloying of germanium with traces of antimony for use in transistors.

It is possible that technology will advance sufficiently to take advantage of the removal of impurities and thus extend to better applications the vast reservoir of material which may contaminate another. For example there are approximately 200,000 tons of good copper in the annual steel production of 120,000,000 tons. Three hundred fifty thousand tons of copper in as much steel will make the steel difficult to hot-work and to forge into useful shapes. The copper, unnecessarily alloyed in the steel, represents about one-sixth of our present annual copper needs.

Who can predict by what brilliant stroke of metallurgical genius an economical way may be found to remove this unwanted copper contamination from the vast recycled tonnage of steel?

The removal of contaminants and impurities from our primary metals has lifted a large curtain of ignorance about the properties of pure metals. It was only a few years ago that textbooks classified pure manganese, chromium, vanadium, titanium, and zirconium as hard, brittle metals. Actually, these pure metals have been shown to be quite the reverse when the minute amounts of extraneous materials and alloys were removed. These pure metals are known to be ductile and tough. They can be cold-worked and drawn through dies.

The use of radioactive isotopes is just beginning to take a foothold in telling the engineer what takes place as metals are contaminated by impurities, or conversely, intentionally alloyed. An alloy containing a small percentage of radioactive phosphorus would tell by its emissions just how well the alloy diffused since the radioactive phosphorus would be present wherever the alloy was present. By similar means the analysis of the alloy present in the total cast can be quite rapidly computed by the quantitative count of the radioactive emissions. This kind of technique could be developed for knowing the state of the alloyed metal while it is liquid and before it was cast. Such practice would conserve scarce alloys.

The blends of polymers in plastics are being computed by using radioactive carbon in certain of the compounds. Long and tedious chemical determinations are bypassed with these new techniques and actually give the engineer a greater knowledge of the product than he could obtain by ordinary analytical methods. Uses of byproducts of nuclear fission bid fair to exceed the importance of the release of energy in this spectacular development.

The purity of refined gold is a long distance from what today is considered to be a pure metal. For example, refined gold at 99.6% contains 0.4% of other alloys or impurities; whereas in the realm of thermonuclear metals the impurities must be reduced to one part in 100,000,000.

4. Making Our Metals Do More

Cladding and coating of metals to protect them from corrosion and pitting have extended their life many times. Lead-coated steel, known as "terneplate," galvanized steel, both hot-dipped and electrolytically plated zinc, and aluminum-coated steel are common articles of commerce. Though less of the protecting metals are being used today, they are doing a better job by reason of the better methods of processing and processing controls.

Measuring continuously the minimum required thickness of metal coating by the use of radioactive isotope scanning devices assures the desired plating thickness without wasting the coating material. In this manner, less metal has been spread over more area with assurance of equal protection.

The huge scrap pile of millions of machines each year that were junked because the mating parts had lost a few thousandths by wear is a staggering toll to pay for that minute ratio of metal loss. For example, four ounces of metal lost by wear from the vital parts of a 4000 lb automobile may be all the weight difference between a noisy, unsafe machine, ready to be junked, and what the machine weighed when new. How can the camshaft lobes, the valve lifters, the rocker arms, the piston rings, the power train gears be made to wear very much less rapidly? What metal surfaces are more compatible, will abrade each other less, than those we are now using?

How may better heat-conducting metals, or composites, reduce operating temperatures, equalize temperature gradients and make higher pressures and higher outputs possible?

One successful example of this type was the ex-

[12] *Scientific American*, July, 1954, p. 36.

haust valve. First, it was made of conventional ferritic alloy steel. Then, as the output for displacement increased, the austenitic steel valve with higher hot hardness and greater corrosion resistance became available. More recently as the temperatures and pressures were stepped up further, the austenitic valve was hollowed out, and the void filled with metallic sodium. This gives a twofold cooling means, that is, absorption of heat by melting the sodium and sloshing it about from head to stem for better heat transfer.

Making Stresses in Metals Work for Us

One of the most baffling problems of the engineer is the untimely and sometimes catastrophic failure of metal components. Why did the steel cable spun for the Ambassador Bridge fail, replacement bankrupting the contractor?

Why did so many welded tankers and freighters suddenly split asunder and dive into the devouring depths of the insatiable ocean?

Why have steam turbines made a shambles of substations when the rotor exploded?

What made the railroad rail fracture when the streamliner rounded the curve?

The designs were admittedly satisfactory since the majority of similar structures continued to give satisfactory service, free of trouble. Did the fault lie in the material? That is the usual question, and too often assumes its own pre-judged answer.

The principal unknown fact has been the nature and arrangement of stresses and stress-raisers which induced the failures. For example, minute corrosion pits probably made the wire rope inelastic.

Sharp hatch corners, poor welding and falling temperature triggered the fracture through the poorly deoxidized ship plates.

Internal fissures or separations which act as high stress concentrators are legitimately blamed for the rotor and rail failures.

As stresses act to destroy, cannot stresses also be made to help preserve the structure?

With the knowledge of stresses and their measurement, which the SAE has fostered and continues to develop, the beneficial arrangement of stresses *can* be made helpful.

Beneficial residual stresses can and are being used to extend the life and raise the safety factor of many components of machines. For example, in aircraft the gears, the connecting rods, the crankshafts, the rocker arms, the valve springs and many other parts of the powerplants and power train are shot-peened to make less metal do more work and do it with reliability.

The beneficial arrangement of stresses also increases the pay load of trucks, tractors, and trains with advantages in saving of weight and material. The "shell" hardened axle shaft and the cold-worked leaf spring are good examples of reduced sections made to do more work. Stress analysis takes off the dead weight of a part and so redistributes the metal that it withstands a greater imposed load than it could have done originally.

5. The Distant Look Ahead

One thing is apparent from the review of the state of development and use of metals at the present time. It's that our long-range view has in the picture continuous expansion in the use and application of the alloys of iron, notably the common constructional steel, the low-alloy high-strength steel, and particularly the increase of steel alloys inherently resistant to corrosion, or steel overlaid with protective shells of other metals or materials such as the sandwich construction. Since iron is relatively so abundant and is comparatively so easily reduced from its ores, and has such remarkable combinations of fabricating characteristics, it is most likely that it will retain its preeminence among the constructional metals.

The relative abundance of the ores of aluminum and the continuous opportunity for obtaining cheap electrical energy from fossil fuels, water falls, and atomic sources, leave little doubt that its rapid expansion in the field of constructional metals will continue. At the moment it represents only about 1 to 1½% of steel output. It is entirely probable that it may gain as much as a 3 or 4% ratio to steel.

Lightness and ease of fabrication as well as natural resistance to corrosion give aluminum this preferred position among the constructional metals.

Magnesium, with its inexhaustible occurrence in the earth and in the sea, waits only a greater permanency of protection from corrosion to achieve a higher ratio to aluminum in the field of light metal construction. The recent expansion of extrusion and wide sheet rolling facilities by its principal producer will greatly accelerate the constructional applications of magnesium and its alloys.

Due to the unusual combination of the properties exhibited by titanium, namely lightness with high strength, resistance to higher temperatures than either aluminum or magnesium, and its favorable ratio of elastic modulus to weight will continue to push titanium output into tonnage usage, now considered speculative.

The special qualities of zirconium, particularly with reference to thermonuclear reactions and its unwillingness to retain neutrons will give it an impetus that can only be paced by the expansion of atomic power developments.

Turning from the metals to the nonmetallic field, there is little question that the plastics, including all the elastomers, of which indispensable rubber was the precursor, are calculated to offset many millions of tons of metals which might otherwise have been used. In addition to that, combinations of metals and plastics will further encroach upon the application of metals through sandwich and filler constructions.

Research into the properties and improvements of glass will assure that its usage in automotive vehicles will not be readily displaced. Even though plastics have gained considerable acceptance as transparent materials in aircraft, glass has many desirable properties not equaled by them.

For reasons not well understood by each passing generation, the exhaustion of one plentiful resource is paralleled by the discovery of an alternate.

SAE in Fuels and Lubricants *Yesterday Today Tomorrow*

by T. A. Boyd

WHAT, first of all, of tomorrow?

The future of cooperative research in the field of fuels and lubricants seems certain to be even more significant than its past. And thus far such cooperation has been highly constructive and profitable. This it has done by serving as a vital leaven and auxiliary to individual or private investigations in the field.

It is here assumed that for automotive vehicles, including aircraft in part, fuels and lubricants will for some time to come continue to be hydrocarbons, probably mostly from petroleum. But the prophet must expect his predictions to prove wrong in some respects. Thus Thomas Midgley, Jr. addressing the Midwest Section, SAE, in 1924, expressed the belief "that 6½ to 1 compression ratio will be the maximum that can be used practicably"[1].

How wide of the mark the passage of 31 years has proved that prediction to be! It was nevertheless made by a man with an uncommon gift of foresight and optimism.

So, although myself very much of an optimist on the subject, I shall make few specific guesses about the future of fuels and lubricants. Instead, I will mention some of the more important problems still in urgent need of solution—or of better solutions than have yet been found—which in some measure are amenable to cooperative attack.

These, then, are some of those problems:

- **Finding a still better corrective for combustion chamber deposits and the surface ignition resulting from them.**

- **Providing lubricating oils which will minimize the increase in octane requirements with service.**

- **Finding better means of predicting the storage stability of gasolines. This may demand an understanding of oxidation mechanism in gasoline components.**

- **Coming at simpler and less time consuming tests for the oxidation-corrosion stability of lubricating oils.**

- **Insuring against excessive wear under**

[1] *SAE Journal*, Vol. 14, June, 1924, p. 574.

3 HUNDRED BILLION DOLLARS . . .

. . . that is what we Americans have spent for fuels and lubricants during the 50-year lifetime of the SAE.

This article relates to the cooperative enterprises of those who have been striving to give people better and better fuels and lubricants for their money. A large part of those endeavors has been conducted within the SAE, or in groups of which the SAE was godfather or sponsor.

One of the organizations sponsored by the Society, and one of the most important, is the Coordinating Research Council, together with the different cooperative groups which preceded it and led up to its organization in 1942.

some of the more severe operating conditions.

• Learning more about lubrication, especially under so-called boundary lubrication conditions.

• Getting better knowledge of the relationship between molecular structure in lubricating oils and their physical properties, such as change of viscosity with temperature.

• Dredging out a more complete and useful understanding of the mechanism of combustion as it occurs in the gasoline engine, in the diesel engine, and in the gas turbine.

• Getting a more minute knowledge of the composition of automotive engine exhaust gases . . . this with a view toward so improving the totality of combustion as to eliminate from engine exhausts the small amounts of unburned hydrocarbons and other combustibles they contain.

Through future research acceptable solutions to all these problems should be found, and in most cases will be found. Some of them have already been solved in a partial way. And cooperative research will continue to aid mightily toward that objective, just as it has in the past.

1. The Birth of Cooperative Research

Now this cooperation between men from different concerns and different industries in the effort to improve a product or a process is something new under the sun. It came into being within the lifetime of the SAE, and in large part through the SAE and other technical societies. The topmost form of such cooperation—that in which men assemble at a common place and jointly engage in extensive experimentation, such as was done by the Cooperative Fuel Research Committee at Uniontown in 1932 and 1934—is so new that it has only just come of age.

The conception of the method of cooperation as a vital aid to progress, together with the development of means for putting it into practice, is of course a real invention. So far as fuels and lubricants are concerned, that invention had its origin in the SAE about 35 years ago. The man who actually had the first conception of the idea cannot be named, for it was the result of a slow development in which many men had a part and one which was hammered out by trial and error in a gradual evolution.

But these, in alphabetical order, are the names of a half-dozen of the better known men who had important parts in the origination of the idea and in putting it into practice: Bachman, Clarkson, Crane, Dickinson, Horning, Kettering. All of these except Coker Clarkson, secretary and general manager of SAE for many years, are men who served also as president of the Society.

Like the saying that the greatest invention of all was the invention of the method of invention, cooperative research is itself one of the biggest advances in the technology of fuels and lubricants. Not to be underestimated either is the importance of this statement made in 1946 by John A. C. Warner: "The friendships and understandings that have been developed among men are among . . . the greatest products of the (CFR) work."

"In 1907," it is recorded in the *SAE Journal*, "engi-

neers began to be worried about fuels because, they said, there isn't enough gasoline to go round and what are we going to do when the supply gives out? . . . That same year, the engineers were becoming lubricant conscious, one of them observing plaintively: 'An impression that ball bearings will operate without lubricant is more general than one might think' "[2].

By 1918 A. Ludlow Clayden told the SAE Metropolitan Section, "We are nearly at the end of gasoline as we know it"[3]. In a paper before SAE in 1919, David White of the U. S. Geological Survey, too, said that "The peak of production (of petroleum) will soon be passed—possibly within three years"[4].

In 1913 the Council appointed a Fuel Committee. It was a subcommittee of the Miscellaneous Division of the Standards Committee. But it did not function long. In September, 1917, the Council established in its stead a Fuels and Lubricants Division.

Then, in the report of the 14th Annual Meeting (1919), it was said that "President Kettering's address on the more efficient utilization of internal-combustion engine fuel was of the greatest value and held the members spellbound"[5]. As a result of that address and the considerable discussion which followed it, the Council voted that spring of 1919 to supplant the Fuels and Lubricants Division by a Research Committee. B. B. Bachman was named chairman of the Research Committee and its "prime problem" was to consist "of matters involved in the present fuel situation"[6].

Now some things began to be done. An entire day was "spent at Washington in April (1919) in discussing various phases of the subject." Another meeting of the Committee was held in New York that same month of April at which a resolution was adopted "to the effect that a committee to be known as the Automotive Fuel Committee, composed of representatives of the Government, the Society of Automotive Engineers, the National Automobile Chamber of Commerce, the Motor and Accessory Manufacturers' Association, and other organizations interested in the problems involved, should be formed to consider the fuel situation and promote research intended to aid in the problem of insuring an ample supply of engine fuel"[7].

The record for that same summer of 1919 shows that "The SAE Research Committee . . . has been instrumental in bringing about two important meetings between representatives of the automotive and the fuel industries"[8]. The first of those meetings was held at the University Club in New York on August 21. John N. Willys, representing NACC, presided at that meeting, which was attended by 9 representatives of automotive groups and by 8 representatives of the petroleum industry. Coker Clarkson presented there a statement prepared by the SAE

[2] *SAE Journal*, Vol. 37, July, 1935, p. 23.
[3] *SAE Journal*, Vol. 2, January, 1918, p. 46.
[4] *SAE Journal*, Vol. 4, May, 1919, p. 363.
[5] *SAE Journal*, Vol. 4, March, 1919, p. 137.
[6] *SAE Journal*, Vol. 4, May, 1919, p. 367
[7] *SAE Journal*, Vol. 5, August, 1919, p. 99.
[8] *SAE Journal*, Vol. 5, September, 1919, p. 195.

SAE Golden Anniversary Author

T. A. Boyd

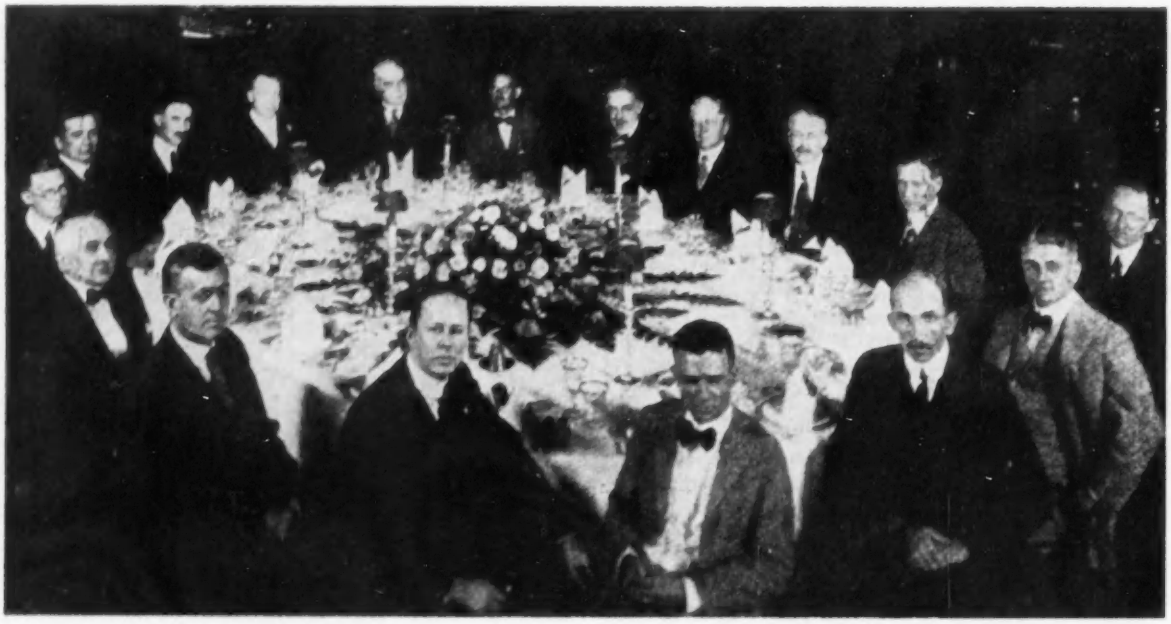
T. A. Boyd has been associated with General Motors Research Laboratories and its predecessors since 1918. He is now research consultant with that organization.

Boyd was born in Fairview, Ohio on October 10, 1888. He is an alumnus of Ohio State University, having received his bachelor of chemical engineering degree in 1918 and the degree of chemical engineer in 1938. In 1939 the University awarded him the Lamme Medal for meritorious achievement in engineering and in 1953 the honorary degree of Doctor of Science.

His research has centered around automobile fuels and the problem of engine knock. Along with C. F. Kettering and Thomas Midgley, Jr., he helped uncover the antiknock effects of lead compounds.

After graduating from Ohio State in 1918, Boyd went to work as a chemist with the Research Division of Dayton Metal Products Co., which was absorbed by General Motors Corp. in 1920 and made its central research division.

Boyd has been very active in technical organizations. He joined SAE in 1927, and received SAE's 1948 Horning Medal for his paper "Pathfinding in Fuels and Engines." He is also a member of the American Chemical Society, the Society of the Sigma Xi, the American Petroleum Institute, the Michigan Academy of Arts and Sciences, and the Engineering Society of Detroit. He is a fellow of the American Association for the Advancement of Science, and chairman of Committee D-2 on Petroleum Products and Lubricants of the American Society for Testing Materials, as well as past president of ASTM.



First meeting at University Club, Aug. 21, 1921, of nine representatives of automotive group and eight representatives of petroleum industry

representative, C. F. Kettering, who had had to leave shortly before on a trip abroad. The fuel problem has an automotive industry side and a petroleum industry side, that statement said, and "a complete solution in either case is impossible without the hearty cooperation of both industries." At that meeting, "There were many expressions of a desire for hearty cooperation on both sides"[9].

The Automotive Fuel Committee met next in Chicago, September 29. At that meeting H. L. Horning was elected chairman of the committee and the discussion related mostly to the formulation of a definite list of problems relating to gasoline and its use which needed solution[9].

The next important event leading to cooperative endeavors between the two industries concerned was the annual meeting of the American Petroleum Institute held at Washington in November, 1920. Of that meeting Coker Clarkson wrote: "It was the occasion of continued and increased cooperation of the Society and Institute. Past-President Kettering (who had been named by the Council as representative of the Society, and who emphasized again the need for cooperative effort) gave an epoch-making address as accredited spokesman of the automotive industry. Two technical sessions on automotive fuels and lubricants subjects were held, with H. L. Horning, chairman of the SAE Fuel Committee, and H. M. Crane, a member of this committee, as presiding officers"[10].

Soon afterwards, in the early part of 1921, a meeting of a "Joint Technical Advisory Committee on Efficient Utilization of Petroleum Products" was called by Van H. Manning, director of research for the American Petroleum Institute, "to discuss the joint responsibilities of the petroleum and the automotive industries with regard to present and probable future supplies of motor fuel." In that conference it was agreed to concentrate all available research efforts on how "to adjust the quality of gasoline so as to meet the condition of maximum utility." For this it was deemed necessary to know, first, the relation between volatility and fuel consumption (an automotive industry problem); and, second, the relation between volatility and the yield of gasoline per barrel of crude (a petroleum industry problem)[11]. It may here be noted that neither higher efficiency through better octane number and boosted engine compression, nor more gasoline per barrel of crude through improved methods of refining, was included then.

The Society, which during the summer of 1920 had begun to sponsor experimental work on fuel economy at the Bureau of Standards[12], undertook to secure funds for the more extensive investigations now to be carried on at the Bureau of Standards and the Bureau of Mines. The problem was presented to the National Automobile Chamber of Commerce and the American Petroleum Institute. "The two organizations voted to share in the expenses, and very hearty promises of cooperation were received from individual companies"[11]. For several

[9] *SAE Journal*, Vol. 5, November, 1919, p. 359.
[10] *SAE Journal*, Vol. 7, December, 1920, p. 500.
[11] *SAE Journal*, Vol. 11, September, 1922, p. 249.
[12] *SAE Journal*, Vol. 7, August, 1920, p. 131.

years afterwards the NACC and the API continued to contribute to this research program in its different phases.

In that year of 1921 also, after "extended discussion," the Society set up a Research Department and H. C. Dickinson came from the Bureau of Standards to be the head of it. The object of the Research Department was "To secure from all possible sources, through concentrated effort, more and better fundamental technical information for the use of the members of the Society, and to make this information more easily available"[13].

2. Car Tests Come into the Picture

Although part of that early cooperative fuel research was carried on at the Bureau of Standards and the Bureau of Mines and supported in part by contributions from industry through the NACC and API, it is to be noted that another part of it was conducted by the direct cooperation of interested concerns within the automotive industry. About 10 companies cooperated in running a series of car tests "intended to show under normal everyday running conditions with average drivers what effect distinct differences in fuel volatility have on the total fuel used per mile of travel . . . An essential point was that the drivers should not know what grade of fuel they were using at any time until the tests were completed." For these tests four gasolines of widely different boiling ranges were supplied by members of API [11].

These were the results of those car tests: "The ordinary passenger automobile driven in summer shows no difference in the number of miles per gallon that can be obtained with gasoline of volatilities varying within the limits represented by fuels A to D"[14]. However, "The winter tests (run later) showed a slight increase in average fuel consumption for the increase of 55 F in the 90% point of the distillation curves . . . Drivers agreed that the more volatile fuels were superior as regards starting and general performance"[15]. The latter quotation is from a report by John A. C. Warner, who in 1923 had become manager of the SAE Research Department.

By May, 1924, the "Joint Technical Advisory Committee on Efficient Utilization of Petroleum Products" was called more simply "The Joint Committee on Fuel Research". At a meeting at the Bureau of Standards, with T. G. Delbridge in the chair, "great satisfaction in the Bureau's work was expressed by representatives of both the automotive and the petroleum industry . . . Regarding future work, it was recommended that the investigations include crank-case oil contamination, easy starting, and coordination of engine design and fuel volatility"[16]. By September, 1924, the name,"Cooperative Fuel Research Committee," appeared in reports[17].

Then in 1926 it was reported that "The performance of motor fuels and methods of measuring their volatility and crank-case oil contamination have constituted the three major divisions of the Cooperative Fuel Research." Many papers reporting results of research in these areas, mostly by members of the Bureau of Standards staff, were published in the *SAE Journal* from time to time. Over a period of years, those papers bore such names as Dickinson, Carlson, Lee, Birdsell, Eisinger, Sligh, Sparrow, Cragoe, Brooks, Cummings, and Bridgeman.

In a review of SAE Research activities in 1930, on the occasion of the 25th Anniversary of the Society, some of the tangible results of the Cooperative Fuel Research up to that time were enumerated as follows: "Improved quality of gasoline, together with an increase in yield per barrel of crude; coordination of engine design and fuel characteristics, resulting in easier starting, better acceleration and improved performance in general; significant steps toward preventing crankcase oil dilution and its accompanying ills; and the prospect of writing gasoline specifications based on fundamental knowledge that will have a true bearing on car performance"[18].

3. Launch Search for an Antiknock Yardstick

Earlier—in June, 1926—appeared this item: "A new phase of the Cooperative Fuel Research is the study shortly to be entered upon of methods now in use of measuring the antidetonating qualities of motor fuels"[19]. Then a few months later this is said: "Considering the lack of a generally accepted method for measuring the antidetonating qualities of gasoline as a handicap to systematic research in this field, the Cooperative Fuel Research Steering Committee (note the added word) at its April 23, 1926, meeting incorporated in its program a survey of the methods now in general use with a view to the ultimate general adoption of some one method" [20]. The survey paper referred to was prepared by

[13] *SAE Journal*, Vol. 9, December, 1921, p. 437.

[14] *SAE Journal*, Vol. 12, January, 1923, p. 3.

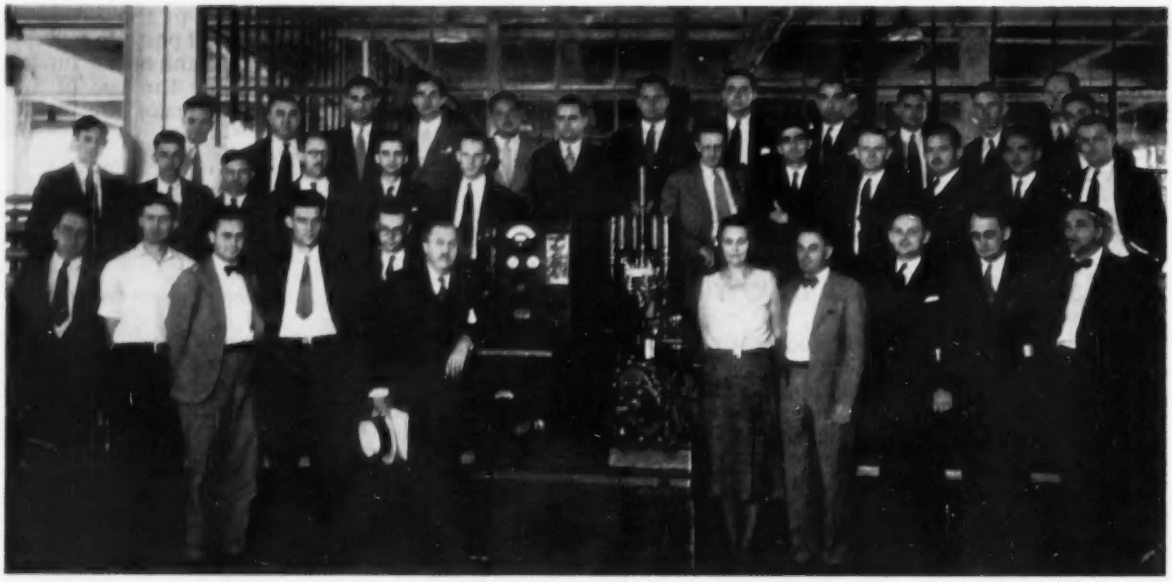
[15] *SAE Journal*, Vol. 14, February, 1924, p. 151.

[16] *SAE Journal*, Vol. 14, June, 1924, p. 582.

[17] *SAE Journal*, Vol. 15, September, 1924, p. 183.

[18] *SAE Journal*, Vol. 26, June, 1930, p. 713.

[19] *SAE Journal*, Vol. 18, June, 1926, p. 573.



1932 CFR Detonation Subcommittee gathered at Waukesha Motor Co. at invitation of H. L. Horning to work out modifications of knock testing apparatus and procedure resulting in CFR Motor Method

H. K. Cummings and published in May, 1927[21]. In that paper the widely varying methods used in more than ten laboratories at that time are described in some detail.

These events followed a Detonation Symposium at the 1927 Annual Meeting of the Society at the conclusion of which was presented a progress report of the Research Subcommittee (of the SAE Research Committee) on Causes and Effects of Detonation. The members of that subcommittee were Thomas Midgley, Jr., chairman, T. G. Delbridge, S. W. Sparrow, and R. E. Wilson[22].

In the winter of 1927-28 the first survey of the antiknock quality of the automobile gasolines then being sold in the United States was conducted for the Cooperative Fuel Research Committee by the Bureau of Standards. Only 15 gasolines were included however. The results were reported simply as per cent better or worse than the reference fuel then in use at the Bureau of Standards, and the range in knock rating was considerable.[23]

Also, during 1927 nine laboratories employing different methods cooperated in the measurement of the knock characteristics of five selected gasolines. This was not a committee endeavor, but one organized privately by Graham Edgar. For some fuels there were considerable divergencies in the results obtained by the different methods[24]. A similar program was conducted by Neil MacCoull, also, with like variability of results[25].

Following that—at its February, 1928, meeting—the Cooperative Fuel Research Steering Committee voted to set up a Subcommittee on Methods of Measuring Detonation. A. Ludlow Clayden, chairman for that day (the CFR Committee did not have a permanent chairman), appointed these men as initial members of the new subcommittee: D. P. Barnard, H. C. Dickinson, Graham Edgar, J. Bennett Hill, H. L. Horning, and Neil MacCoull, with the author of this paper as chairman, and C. B. Veal (ex officio) as secretary. (Veal had become Research Manager of SAE in 1926.) The assignment was to develop an apparatus and method for making knock ratings, together with suitable reference fuels which would enable everyone doing knock testing to talk the same language. Under the existing conditions of diverse apparatus, methods, and reference fuels, this was not then possible[26].

During the first year of its existence the Detonation Subcommittee held five meetings and at every one there was a perfect attendance. The members quickly agreed that the first thing to do was to design and build an engine suitable for knock testing so that the experimental work of everyone could be done on a common basis. The vital job of designing and building such an engine was taken on by H. L. Horning and done at his Waukesha Motor Co. with the able assistance of Arthur W. Pope, Jr.

After many meetings of the Detonation Subcommittee and much experimental work and coopera-

[20] *SAE Journal*, Vol. 20, February, 1927, p. 176.
[21] *SAE Journal*, Vol. 20, May, 1927, p. 599.
[22] *SAE Journal*, Vol. 20, February, 1927, p. 189.
[23] *SAE Journal*, Vol. 22, April, 1928, p. 455.
[24] *SAE Journal*, Vol. 22, January, 1928, p. 41.
[25] *SAE Journal*, Vol. 22, April, 1928, p. 457.
[26] *SAE Journal*, Vol. 24, February, 1929, p. 212.

tive testing, the CFR Committee at its meeting on September 14, 1931, approved the apparatus and procedure for measuring the knock characteristics of gasoline in terms of octane numbers, as developed and recommended then by the Detonation Subcommittee[27]. The octane number scale was based on a proposal that had been made by Graham Edgar in 1927[28]. The method was then adopted by the Society as Recommended Practice[27], and in 1932 it was published by the American Society for Testing Materials as a Proposed Method for Determination of Knock Characteristics of Motor Fuels.

Along the way, in early 1930, an invitation had been extended to the British group working along similar lines in the Institution of Petroleum Technologists to purchase the equipment and join the CFR Detonation Subcommittee in some of the rating programs. That invitation followed soon after the receipt of a joint letter from A. E. Dunstan of the Anglo-Persian Oil Company, F. H. Garner of the Anglo-American Oil Company, and J. Kewley of the Asiatic Petroleum Company, suggesting cooperation in the field.

The invitation was accepted, and a year later three men from England attended the Detonation Symposium at the 1931 SAE Annual Meeting, which was reported as follows: "The Detonation Subcommittee of the Cooperative Fuel Research Steering Committee occupied a premier position in the Annual Meeting Program, not only as sponsor for the most spectacular and best attended session but as host to Messrs. R. Stansfield, C. H. Barton, and C. H. Sprake, co-authors of a contribution to the Detonation Symposium and representatives of the British cooperating committee of the Institute of Petroleum Technologists"[29].

The Detonation Subcommittee next took up the question of adapting the new method to testing aviation gasoline. A meeting was held with men from the Army, the Navy, and the Aeronautical Chamber of Commerce. This resulted later in the formation of the CFR Aviation Gasoline Detonation Subcommittee, of which Arthur Nutt was the first chairman, and which soon evolved a tentative procedure for rating aviation gasolines[30]. Their work, which involved extensive testing with full-scale airplane engines, led after a while to the test procedure known as the 1-C Method, which in 1941 was standardized by the American Society for Testing Materials.

Still later the experience of World War II demanded the measurement of the knocking behavior of the very rich mixtures employed in take-off. Again, in cooperation with engine makers and military agencies, the Aviation Gasoline Detonation Group developed the supercharged knock test method which became known as the 3-C Method. This procedure also was adopted as a Tentative Standard by the American Society for Testing Materials in 1947.

4. Need Gives Rise to Motor and Research Methods

In the work of the Detonation Subcommittee came next, and soon, the need to correlate laboratory octane numbers with knocking behavior in cars, for it was found that some so-called "sensitive" gasolines "depreciated", or they knocked worse in some cars and under some driving conditions than the laboratory ratings by the new method indicated. This brought on the historic first Uniontown Tests in the summer of 1932.

An extensive series of knock ratings in cars were first made on the Uniontown Hill (U. S. 40) and participated in by representatives of 12 automotive and petroleum laboratories, as well as of the Bureau of Standards and Yale University. Following that, with some changes in representatives participating, the group gathered at the Waukesha Motor Company on the invitation of H. L. Horning and worked out there by experiment, using the same fuels, modifications of the knock testing apparatus and procedure to give the best possible correlation between laboratory ratings and the road ratings as just obtained at Uniontown.

A portion of the report from the *SAE Journal* of that two-part program follows[31]: "A truly remarkable project of cooperative research has recently been completed by the detonation group of the Cooperative Fuel Research Committee. Aimed at a correlation between road observations of knock and results obtained under laboratory conditions, the experimental work required some 10,000 observations during 2500 runs on Uniontown Hill, plus a great many additional determinations on the CFR engines at Waukesha, Wisconsin.

"Although the test results . . . are in themselves of intense interest, the pleasing culmination of the project is more than significant as a demonstration of the possibilities for achieving an objective through *real cooperation* of capable men and substantial companies."

The knock testing procedure as thus modified was called the Motor Method, and the original procedure, which was not discarded, was then named the Research Method. The new method was adopted by the American Society for Testing Materials in 1933 as the Tentative Method of Test for Knock Characteristics of Motor Fuels.

Another and still more extensive series of cooper-

[27] *SAE Journal*, Vol. 29, November, 1931, p. 352.
[28] *SAE Journal*, Vol. 20, February, 1927, p. 245.
[29] *SAE Journal*, Vol. 28, February, 1931, p. 265.
[30] *SAE Journal*, Vol. 34, March, 1934, p. 19.
[31] *SAE Journal*, Vol. 31, October, 1932, p. 20.

Participants in first series of cooperative knock rating road tests conducted at Uniontown Hill U.S. 40. Group represents twelve automotive and petroleum laboratories, Bureau of Standards, and Yale University. It made some 2,500 runs and 10,000 observations on different fuels

ative tests was run at Uniontown in 1934—this time with participants from England, France, and Canada—for the purpose of checking the continued correlation of the road results with ratings by the Motor Method. Still other cooperative correlation tests were run later, notably at San Bernadino in 1941, where 24 test cars were driven over 100,000 miles[32].

These continuing efforts have shown that no single laboratory test completely evaluates a gasoline for knock in all its uses. The result is that both the Motor and Research Methods have been standardized and are in alternative use today where the ratings apply best.

The several cooperative road test programs did much to develop a generation of young men who understood each other's technical problems and who in later years were to serve their country well in solving wartime problems in fuels and lubricants, and also to assume large responsibilities in their respective companies. Here it was that first began to be heard the now familiar names of Walter Ainsley, Slim Boldt, Frank Burk, John Campbell, Bob Greenshields, Bill Holaday, Ray Potter, Jack Sabina, and Gil Way, to name only a few.

In 1936, twice-yearly exchange programs were set up by the CFR Committee to make periodic checks of the reproducibility of the laboratory knock testing method. (This activity was later turned over to Committee D-2 of the American Society for Testing Materials.) In that year of 1936 also Professor Herbert W. Best became chairman of the Detonation Subcommittee, and later the name of this group was changed to the CFR Motor Fuels Committee and its scope extended to include volatility as well as detonation.

Acting on the petition of many interested persons, the Society formed at the 1933 Annual Meeting a new Professional Activity, the Fuels and Lubricants Activity[33]. The Council appointed A. E. Becker as the first Vice-President of the new Activity. In all the years since, the Fuels and Lubricants Activity at its three meetings each year has formed one of the most important forums for bringing out new knowledge in its field.

Through these years the SAE Research Committee and the CFR Committee were active in other fields besides those mentioned thus far. One of these was in respect to the solution of vapor lock difficulties in aviation engines and in automobile engines[34]. Another endeavor was the cooperative work begun in 1933 by the Volunteer Group for Compression Ignition Fuel Research, T. B. Rendel, chairman, which successfully developed apparatus and methods for measuring the ignition quality of diesel fuels[35].

It may be noted here that the word "Volunteer" in the designation of the committee just mentioned is of special significance in respect to cooperative research. In the nature of things, those who engage in cooperative endeavors must be volunteers. For such work is simply not done unless those engaged in it think it is of sufficient importance to be worth while doing, or unless they have enough interest in the problem to contribute to it time—and, in some cases, money also.

It was in 1938 that Mrs. Harry L. Horning and the Society established the Horning Memorial Award. The purpose of the Award is to stimulate the quest and conquest which brings "new contributions to existing knowledge of the art of mutual fuel and engine adaptation." It is a fitting memorial to Harry L. Horning and the earnest efforts he made during his lifetime to further progress in the field of fuels and engines.

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[32] *SAE Journal*, (Transactions), Vol. 48, May, 1941, p. 193.

[33] *SAE Journal*, Vol. 32, February, 1933, p. 12.

[34] *SAE Journal*, Vol. 43, November, 1938, p. 20.

[35] *SAE Journal*, (Transactions), Vol. 43, November, 1938, p. 453.

5. CRC . . . a New Center for Cooperative Research

In the *SAE Journal* for June, 1942, was this announcement: "A new organization, the Cooperative Research Council, sponsored jointly by the SAE and API, has been created to centralize, correlate, and promote cooperative research activities of the automotive, aeronautical, and petroleum industries. The Council formally began operation . . . on May 1 . . . .

"The Cooperative Research Council consists of 12 members appointed to serve one year, 6 representing the SAE and 6 representing the API . . . At the organization meeting of the Council on April 13, B. B. Bachman was elected chairman, and T. G. Delbridge vice-chairman. C. B. Veal, for 16 years SAE research manager and secretary of the Cooperative Fuel Research Committee, has been appointed secretary (and manager) of the Council, and R. P. Anderson . . . has been named treasurer . . . 'The purpose of the Cooperative Research Council shall be to direct cooperative research in developing the best combinations of fuels, lubricants, and equipment powered by internal-combustion engines' "[36].

The step of setting up an organization to take over the work of the CFR Committee and to widen the field of such cooperative work, was taken only after lengthy consideration and much debate. The new organization was incorporated in the State of New York on December 13, 1943, under the modified name, the Coordinating Research Council. The modification in name was dictated by New York State law which reserves the word "cooperative" for use by farmers.

At the time of the incorporation, the SAE representatives on the Coordinating Research Council were B. B. Bachman, president, J. M. Crawford, William Littlewood, J. B. Macauley, Jr., Arthur Nutt, and C. G. A. Rosen. The API representatives were T. G. Delbridge, vice-president, D. P. Barnard, A. Ludlow Clayden, R. A. Halloran, K. G. Mackenzie, and G. G. Oberfell.

As is stated above, the field of the Coordinating Research Council included lubricants, and all the lubricating research activities of SAE were now centered in CRC. The lubricants research activities mentioned as then being pursued cooperatively by groups within SAE included the work on crankcase oil stability, on extreme-pressure lubricants, and on aircraft engine lubricants.

Organized by CRC soon afterwards to implement that purpose was a Coordinating Lubricants Research Committee, the first general chairman of which was C. G. A. Rosen[37]. This then seems to be a fitting place to go back and, by means of items from the record, to trace briefly some of the prior work on lubricants done under the auspices of the SAE.

In the report of the first meeting between representatives of the automotive and petroleum industries held in August, 1919, under the auspices of the newly formed SAE Research Committee is this sentence: "Lubrication is mentioned by many as a subject of importance second only to that of fuel"[38]. However, until the formation of the Coordinating Research Council, there was no organization for cooperative research on lubricants comparable to the Cooperative Fuel Research Committee in the field of fuels. Nevertheless, different groups were set up from time to time to further progress in the field of lubricants. Unlike the CFR Committee, these were under the sole sponsorship of the SAE.

At its meeting in May, 1920, the SAE Council established a Lubricants Division of the Standards Committee[38], the first chairman of which was A. P. Eves. Succeeding chairmen, up to the time when the Coordinating Research Council was formed, were H. C. Mougey, W. S. James, and E. W. Upham.

The matter below, consisting mostly of excerpts from the *SAE Journal*, gives just a glimpse of activities over the years by the various SAE groups concerned with progress in the field of lubricants:

● **1925**: A series of proposed crankcase lubricating oil specifications had been set up in 1923 by the Lubricants Division of the Standards Committee (although a still earlier one had been adopted in 1911). But those specifications did not come into general use for the reason that they covered a variety of properties in addition to viscosity[39]. On that account, "It was . . . decided to limit the revised specifications to a system of numbering for the grades of oil and to designate only their viscosity limits at 130 F and 210 F instead of at 100 F as in the present specifications, and to omit other tests such as flash, fire, color, and Conradson carbon"[40].

● **1931**: "The Lubricants Research Subcommittee, which was approved by the Research Committee and the Council at the time of the last Summer Meeting, set forth its purpose as follows: To develop tests to evaluate the properties of extreme-pressure lubricants and to develop tests to determine the lubrication requirements of gears and bearings, with the idea of correlating the tests on the oils with the requirements of the gears and bearings"[41].

● **1932**: "H. C. Mougey, chairman of the Lubricants Research Subcommittee, reported that this group wished to carry on further study on the relation between lubricant characteristics, operating conditions, and design factors under high pressure. He reported the details of the program the Com-

[36] *SAE Journal*, Vol. 50, June, 1942, p. 23.
[37] *SAE Journal*, Vol. 52, August, 1944, p. 25.
[38] *SAE Journal*, Vol. 6, June, 1920, p. 443.
[39] *SAE Journal*, Vol. 16, May, 1925, p. 497.
[40] *SAE Journal*, Vol. 17, July, 1925, p. 33.
[41] *SAE Journal*, Vol. 29, December, 1931, p. 430.

mittee desired to follow this year and requested that the Council approve raising $7,500 in the industry. The Council approved raising the necessary funds in connection with this project"[42].

● **1933**: "New classification numbers for two crankcase oils (10W and 20W for cold weather starting) were approved for trial in connection with the present SAE viscosity numbers at the Standards Lubricants Division meeting"[43].

● **1934**: "W. S. James, chairman of the Extreme-Pressure Lubricants Research Committee, is scheduled to present a progress report of that Committee's work at the Summer Meeting and to demonstrate a machine for testing the load carrying capacity of extreme-pressure lubricants, recently constructed in the shops of the Studebaker Corporation"[44].

● **1935**: "A cooperative program of ring-sticking tests using a group of three test oils has been arranged by the Steering Committee of the Crankcase Oil Stability Research Subcommittee . . . All laboratories in position to participate actively in the committee's work are invited to cooperate in rating oils according to their individual test methods"[45].

● **1937**: "Laboratory tests on these lubricants (hypoid gear lubricants)", reported H. C. Mougey, "have shown very definitely that no single test, except a very severe service test, can be used to determine if a lubricant will be satisfactory in service"[46].

● **1940**: "Early in 1940 it became evident that the present method of test in use on the SAE Extreme-Pressure Lubricants Testing Machine was not properly differentiating between extreme-pressure lubricants for passenger cars and trucks"[47].

● **1942**: "The Testing of Heavy-Duty Motor Oils," a paper "authorized by Subdivision B of the Lubricants Division, SAE Standards Committee, with a view toward the establishment of a test procedure by which so-called heavy-duty motor oil might be evaluated" was presented by Harry C. Mougey and Joseph A. Moller. One of the conclusions was this: "By means of carefully controlled operating conditions, production multicylinder engines can be used, in conjunction with a series of standard test oils, to give a test pattern for these oils which are reproducible themselves, and which will coincide with the results obtained on these oils in service in so far as corrosion and oxidation resistance characteristics are concerned"[48].

The foregoing outline brings the review of work in the field of lubricants forward to the time of the formation by CRC of the Coordinating Lubricants Research Committee under the initial chairmanship of C. G. A. Rosen, mentioned earlier.

The centering of the Society's cooperative lubricants research in CRC did not, however, include the activities of the Lubricants Division of the SAE Standards Committee, now the Fuels and Lubricants Technical Committee of the SAE Technical Board. E. W. Upham served as chairman of that group for over 20 years, from 1928 to 1948, when he was succeeded by M. D. Gjerde. Standardization, not research, has been and is the principal function of this committee. But, in serving also as an advisory body to the SAE Technical Board, as a clearing house for automotive problems in its field, and as a discussion forum for technical men of the automotive and petroleum industries, the Committee has originated progressive activities through recommendations it has made. A recent and notable one of these was promoting the tests by CRC and other groups which provided the basis for including 5W oils in the 1950 revision of the SAE crankcase oil classification.

6. CRC in War and in Peace

As the Coordinating Research Council was formed in wartime, its activities for that period were concentrated almost altogether on wartime problems in fuels and lubricants. As early as 1940 "The growing importance of national defense activities . . . resulted in special emphasis on a number of projects coming under the scope of SAE Research Committee and the Cooperative Fuel Research Committee"[49].

During World War II the newly formed Coordinating Research Council was called upon by more than 30 military and government agencies for assistance in solving technical problems connected with the

[42] *SAE Journal*, Vol. 30, February, 1932, p. 44.
[43] *SAE Journal*, Vol. 33, October, 1933, p. 49.
[44] *SAE Journal*, Vol. 34, June, 1934, p. 23.
[45] *SAE Journal*, Vol. 37, November, 1935, p. 20.
[46] *SAE Journal*, Vol. 40, June, 1937, p. 48.
[47] *SAE Journal*, Vol. 48, February, 1941, p. 59.
[48] *SAE Journal*, (Transactions), Vol. 50, October, 1942, p. 417.
[49] *SAE Journal*, Vol. 47, September, 1940, p. 28.

war effort. At one stage 1500 investigators were working cooperatively on 300 projects involving fuels and lubricants problems[50].

By the end of 1944 this could be said: "CRC's work in recent months was shown (by C. B. Veal) to cover a wide range of projects and products. Engine oil groups are attacking problems of oxidation, low temperature characteristics, SAE 50 grade oils, rust preventives, additives, foaming oxidation stability, and two-cycle engine requirements—and a full-scale test procedure for aviation oils is being developed. Other CRC groups are seeking an all-purpose gear lubricant; are studying vapor lock, equilibrium air distillation, and various detonation problems; are seeking required characteristics for a single universal diesel fuel; are analyzing hydraulic fluids, greases, and cold-weather operation of military vehicles; and are helping to maintain satisfactory service for civilian motor vehicles under wartime conditions"[51].

How well these many responsibilities were discharged is indicated in some measure by the receipt by the Council afterwards of these three awards for meritorious wartime service:

- Ordnance Distinguished Service Award
- Naval Certificate of Achievement
- Naval Ordnance Development Award

After the war, CRC groups returned to the effort to solve peacetime problems, although some of these problems were naturally the same as those which had received attention during the war. There was, for instance, the effect of gasoline in the problem of engine sludge, to which the following relates: "The influence of fuel characteristics was brought into focus as a result of certain military experiences in the Zone of Interior during the last war, and has been followed up by investigations conducted by the Coordinating Research Council. The results of this investigation reported by W. J. Backoff showed that different fuels exhibit markedly different tendencies to cause varnish and sludge, and that differences between fuels in this respect can be determined by a laboratory engine test procedure (CRC Designation FL-2). Up to the time of this report, however, there has been no reliable laboratory bench test for the evaluation of a gasoline to form varnish and sludge"[52].

The following are typical excerpts from the report of activities of CRC during 1948, which showed 73 going projects in all: "One of the most active projects in the Aviation Fuels Division is one covering Low Temperature Characteristics of Gas Turbine Fuels." . . . "The most active project now under way in the Motor Fuels Division is a program to determine the effects of high sulfur in motor fuels on engine performance." . . . "At the request of the Fuels and Lubricants Technical Committee of the Society of Automotive Engineers, the CLR has established a group on Engine Oils Lighter than 10W"[53].

This group made extensive investigation of 5W oils for use in extremely cold climates. As a result, 5W oils, as well as the 10W and 20W oils in use since 1933, were included in the revision of the SAE crankcase oil classification adopted in 1950. On the effects of gasoline high in sulfur, the CRC tests in 62 vehicles showed that the influence may vary from a pronounced effect on cylinder and ring wear at some intermittent operating conditions to no effect under continuous operating conditions at normal engine temperatures[54].

Throughout the after-war years, extensive experimentation continued, too, on lubricating oils containing additives to give detergency, oxidation resistance, or extreme-pressure properties, as well as on improving engine tests on such oils and in trying to find still other and simpler means to determine their suitability and effectiveness. The problem of engine wear was a subject of much discussion and experimentation also.

One of the major problems in respect to the higher compression engines of today and tomorrow, and one to which CRC groups have been and are giving topmost attention, is that of finding a solution to the problem of combustion chamber deposits and their effect on limiting compression by inducing preignition. A great deal of experimental work is being done on the problem in respect to the effects both of gasoline and lubricating oils, and there has been much discussion of the subject within CRC and at meetings of the SAE Fuels and Lubricants Activity. One of the meetings arranged by CRC was an extended symposium and round-table discussion held at Dearborn in late 1952, under the chairmanship of W. J. Sweeney[55].

Although, after 1945, CRC shifted its activities to peacetime endeavors, the following appears in the report for 1950 (by this time M. K. McLeod had succeeded C. B. Veal as manager of CRC): "There has been a marked change during the past year in the general outlook of Coordinating Research Council activity, which has been accelerated during the past few months. This change is the increasing emphasis on military projects, a reversal of the trend which had been evidenced since the end of World War II"[56].

As was said by D. P. Barnard, the "United States has been in either a hot or a cold war ever since CRC was born"[57]. Nevertheless, as Barnard said further, the activities of CRC have been so wide that its "assistance has touched almost everything that moves by internal-combustion engine power on the ground or in the air." How fortunate that there are in existence organizations such as SAE and CRC composed of men with the capabilities and the willingness to devote themselves to the solution of problems of war as well as peace!

Finally, it may be said, as has been said before, that the biggest contribution of cooperative endeavors has been, and no doubt will continue to be, cooperation itself—the opportunity it gives for mutual interchange of ideas and information between automotive and petroleum engineers, thereby stimulating and guiding their own creative efforts.

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[50] *SAE Journal*, Vol. 53, December, 1945, p. 25.
[51] *SAE Journal*, Vol. 52, December, 1944, p. 19.
[52] *SAE Journal*, Vol. 55, September, 1947, p. 54.
[53] *SAE Journal*, Vol. 56, December, 1948, p. 43.
[54] *SAE Journal*, Vol. 58, November, 1950, p. 25.
[55] *SAE Journal*, Vol. 60, December, 1952, p. 98.
[56] *SAE Journal*, Vol. 58, November, 1950, p. 76.
[57] *SAE Journal*, Vol. 60, May, 1952, p. 57.

Future Trends in Automotive Transportation

THE road ahead for the next fifty years looks wide and open to this fleet operator. New designs and materials, and improvements in existing equipment and techniques promise cheaper, smoother, and faster riding.

Just around the curve are streamlined, all-plastic bodies and tubeless tires for heavy vehicles.

• Plastics are light, non-corrosive, comparatively strong, and easy to clean—all desirable characteristics for truck and trailer bodies.

• Air drag can be reduced 25% by merely rounding front corners and trailer roofs. More complete streamlining, particularly at high speeds, will come close to halving the power currently needed.

• Tubeless tires with synthetic cords will give longer life and greater safety, especially if they have deep treads.

• Inside the truck, lightweight, reliable refrigeration will enable commercial operators to keep up with the rapidly growing frozen food business.

Already helping road transportation up the next hill are increased engine power and fuel efficiency.

• Compression ratios in gasoline engines are being increased 10:1.

• Fuel additives and super refining are reducing preignition.

• Superchargers are increasing diesel engine efficiency.

Further down the road gas turbine engines, pushbutton maintenance shops, and automatic transmissions will cause great changes in commercial vehicle operations.

• The gas turbine weighs only 1/8 as much as a similar horse power gasoline engine. It will come into general use as soon as fuel economy can be developed.

• Automatic lubrication and repair equipment, and more automatic engine analyzing equipment will simplify maintenance.

• And with more efficient brakes, transmission and drive components, and better roads, trucks will operate safely at 100 mph.

We are now at a crossroads with over 50 years of experience behind us. We're meeting new problems and mapping the road ahead. Let's take a closer look at the changes we'll be seeing on the highway of tomorrow.

THE LOOK Ahead
1905 A GOLDEN ANNIVERSARY ARTICLE 1955

and Maintenance

by O. A. Brouer

1. Truck and Tractor Design:

Economy the Big Challenge

Some recent advancements include the tilt cab which provides improved cab-over-engine features of shorter overall length, better vision, maneuverability and turning radius, load distribution, and good accessibility to engine and front end assembly for maintenance. Further refinements will be made of this type cab and chassis for steering control and riding comfort. Horsepower and engine efficiency will continue to "grow," nurtured by acclaimed needs of the truck owner and the motoring public.

There is substantial room for improvement between the engine flywheel and the drive wheels. A large amount of development work is going on now in this area. It is nothing to be proud of that, with all drive components performing satisfactorily, there is a loss of 30% in developed horse power from the engine to the drive wheels. This is a real challenge to both lubrication and gear reduction engineers.

In the relatively near future, we shall see several combinations of torque converters and synchronized transmissions. This will be of benefit to truck owners from the standpoint of drivers being able to give more attention to safety in handling their truck

Fig. 1—Automatic transmissions have worked their way into tractor-trailer combinations such as this one

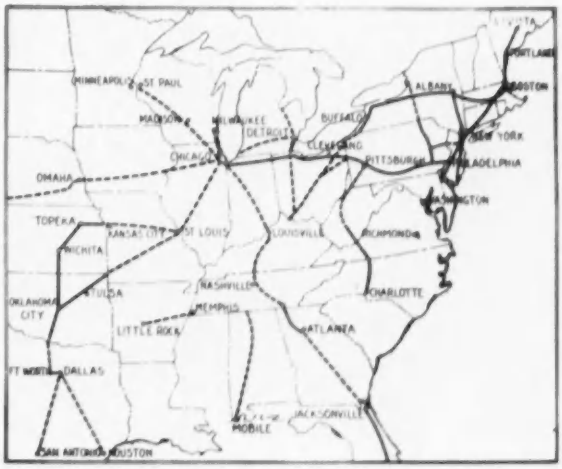


Fig. 2—Higher truck speeds will be realized when this projected super highway system for the eastern United States comes into being

or tractor-trailer combination. To a certain extent it will obviate the skill required today in properly "splitting gears" in the combination of multiple gear reductions. Furthermore, it will prevent the negligent driver from "lugging the engine" with devastating results of this pracice.

One truck manufacturer now has several models in production incorporating automatic transmissions. Competitive tests over an 8-week period show that this unit with 150-hp diesel engine, pulling 32-ft insulated and refrigerated semi-trailer with gross vehicle weight of 50,000 to 52,000 lb, averaged 5¼ mpg. This is approximately 10% more fuel economy than obtained with a similar unit with manual gear shifts. (See Fig. 1.)

In the interim and as a result of a previous well prepared SAE paper on the general subject of gear reductions, some of us operators have been able to do a very much better job of determining gear reductions. We can specify the proper ratios and combinations between transmission and differential so as to obtain more efficient results. Actually it pays to plot the gear reductions in chart form for any heavy duty operation, and experience shows that this is particularly true with heavy-duty highway tractor-trailer units. One manufacturer has simplified this by publishing a book of "Shift Pattern Charts," covering all models and combinations in their current production line.

It was less than 10 years ago that truck speeds of 70 mph were predicted. This has been realized, but has not been common practice, largely because of lack of adequate roads and highways. With the carrying out of PAR (Project Adequate Roads) and a nation-wide system of toll roads in the relatively near future, we can foresee safe truck operating speeds of 100 mph. (See Fig. 2.)

Obviously such speeds with large over-the-road equipment will require more heat resistant tires and more braking capacity than exists today. Even greater improvements will be made in vacuum for smaller trucks, but self contained air brakes or electric brakes, or a combination of both, will be called upon to provide the necessary stopping ability.

Much work is being devoted to design of suspensions to improve upon spring steel. Rubber blocks and air bags are already proving versatile in bus and tandem axle trailer suspension. It is more than conjecture that rubber will play a prominent role in better ride and cargo flotation in the future.

2. *Truck and Trailer Bodies: Plastics to Compete with Light Alloys*

Great strides have been made in the past 10 years in body design and construction, and more are coming. Stainless steel and aluminum alloys have largely replaced wood and "black iron," sometimes disguised as stretcher leveled or blue annealed steel. These new materials have largely thwarted such enemies as deterioration and corrosion.

An example of this (for the benefit of livestock haulers) is a laboratory test over a six-month period of time which shows very slight corrosion on alu-

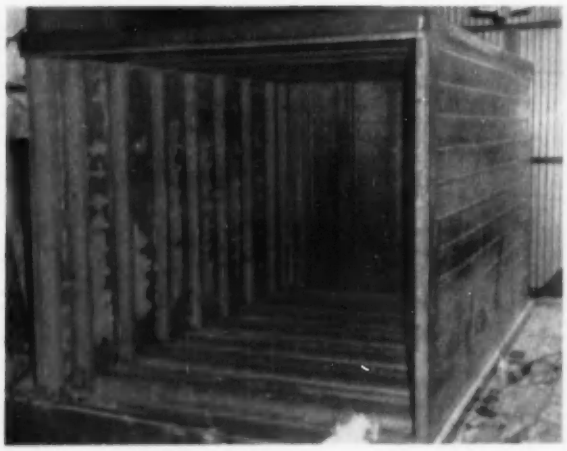


Fig. 3—This 12-ft all plastic body was built to carry perishable products. This view shows sides, top, and bottom, end bonded together, and the fiberglass insulation within the structural members

Fig. 4—Shown here is the rear of the plastic truck body revealing the insulation in place on the inside, ready for the inside lining sheet to be bonded

SAE Golden Anniversary Author

O. A. Brouer is head of the general automotive department of Swift & Co. He has been with Swift since 1925.

Brouer was born in Rhome, Texas in 1902 and is a graduate of the Agricultural and Mechanical College of Texas. He received his bachelor of science degree in chemical engineering in 1925.

Brouer started at Swift as assistant general foreman of adhesive products in Chicago. He became general foreman three years later in 1928 and was appointed to the staff of the president in 1930. In 1933 he was assigned to the automotive department, of which he became assistant head in 1936 and department head in 1940.

He holds patents on several truck refrigeration safety devices and has collaborated with trailer and body builders in the design of specialized bodies for handling perishable products.

O. A. Brouer

For SAE Chicago Section, Brouer served as Transportation and Maintenance Activity vice-chairman during 1945–46 and 1946–47. He was also Section vice-chairman 1948–49. In 1950–51 he was national SAE membership chairman. For the national Transportation and Maintenance Activity, he was meetings vice-chairman in 1952 and became SAE vice-president representing the Activity in 1953.

minum alloy 61ST6 from continuous and repetitive exposure to livestock manure and urine. The interesting part of this experiment is slight surface corrosion during the first six weeks of exposure. This corrosive action then tapered off to the point where it is negligible.

Plastics is a relatively young industry which is growing by leaps and bounds. Some of this growth is being directed into truck and trailer design. Their versatility has been proved in the building of sport car bodies and in trucks and trailers including tank trailers. Plastics offer the following advantages as compared with many other body building materials:

1. Lighter in weight than most metals.
2. Non-corrosive.
3. Easy to clean.
4. Reasonably strong, but may need reinforcement in some instances.
5. Translucent (can be used as skylights in truck body roof).
6. Water proof.
7. Insulating value.

Fig. 5—This 12-ft plastic insulated and refrigerated meat delivery body is mounted on a tilt cab truck chassis. All of its structural members, except for the extruded aluminum floor, are made of fiber glass plastic

The two disadvantages that exist at present are price and lack of resistance to abrasion or wear factor. Rapidly increasing production and competition will serve as leveling factors on price. While commercially practical plastics may never reach the Brinel hardness of steel, it is this writer's opinion that the hardness factor will be improved.

As this article is written, a number of bakery and dairy trucks have been partially constructed using plastics in the bodies and the cabs, and an all plastic meat delivery body is nearing completion. (See Figs. 3, 4, and 5.)

A prediction somewhat more than a dream for

perishable product shippers is truck and semi-trailer bodies built with plastic walls and roof. These walls and roof in place of 3 to 4-in. thickness (including insulation) for 34 to 38 F products, and 6 to 8-in. thickness for frozen products will be 1 to 2 in. in thickness, both inside and outside panels of plastic materials hermetically sealed with a vacuum existing between the walls. The outside panels can be made using the owner's individual color scheme. This will eliminate necessity of painting and polishing, and will assist in appearance from the standpoint of easier washing. Sections of the roof will be translucent to provide natural light for better working conditions.

3. *Truck Refrigeration: Room for Integration with Vehicle Design*

This phase is of interest principally to those concerned with handling perishable product. There are two general classifications—high temperature and low temperature.

In "high temperature" delivery work, such items as fruits, vegetables, dairy, and poultry and meat products, and other foods are handled requiring temperatures of 34 to 38 F. This has been accomplished by two basic methods: first, applying the principle of "hold over", and second, self-contained compressor units. The hold-over system may consist of water ice, dry ice, or hold-over plates. Usually with a eutectic solution inside the plates, freezing is accomplished with ammonia lines with approximately 25 psi suction pressure. This method of refrigerating perishable food items has gained wide acceptance, but further improvements will come about with:

1. Reduction in weight.
2. Forced and controlled air circulation.
3. More nearly leak-proof lines and connections.
4. Less corrosive materials.

Low temperatures of 0 to -10 F are a must in handling frozen foods. Ice cream was, of course, one of the earliest frozen foods. This has now grown to include a large variety of items, such as fruit concentrates, poultry, fish, all types of vegetables, coffee concentrate, and identifiable cuts of meat.

At the current rate of growth, this business, which totaled more than one billion dollars in 1953, will probably amount to five billion dollars annually within the next 10 years. This means more design work for truck and trailer body builders, and also in designing truck chassis to accommodate compartmentalized high and low temperature bodies. Both ammonia hold-over plate type and mechanical compressor type refrigerating equipment are used for this type work. It is anticipated that there will be improvements in weight reduction, reliability in performance, and fully automatic defrosting.

Some recent steps in mechanical refrigeration include a direct-drive gasoline engine generator unit mounted in the "skirt" of the body, and an electric motor direct drive hermetically sealed compressor mounted in the "nose." This gives better weight distribution and provides electric standby drive using 220-v, 3-phase current. (See Fig. 6.) For an average payload of 6000 to 7000 lb (city delivery), ammonia hold-over plate refrigeration with 34 to 38 F body temperature costs approximately 10¢ per hr. Mechanical self-contained units have a total operating cost of approximately four times this figure, but this ratio will be reduced considerably in the near future.

Fig. 6 — This nose-mounted compressor installation represents an advance in mechanical refrigeration. It furnishes better weight distribution and an electric standby

4. *Trailer Design: Aerodynamic Studies Point to Fuel Savings*

Wind resistance has long been a most controversial subject, especially among fleet operators. Recently one of the leading trailer manufacturers, in collaboration with the University of Maryland, made extensive tests of the effect of aerodynamic design on tractor-trailer units. The tractor-trailer models were built to exact one-sixth scale and tested under varying conditions with wind speeds up to 150 mph produced in the wind tunnel. (See Fig. 7.)

It is amazing that using a regular square front trailer requires 54 hp at 50 mph to overcome "air drag" or wind resistance. It is quite significant that the rounding of the front corners using 18-in. corner radius and 6-in. roof radius (see Fig. 8) reduced the air drag at 50 mph, saving 13.2 hp, which is equivalent to 24½%. It was found true that mere rounding of the corners still allows for almost maximum "cube" (cargo space) and is almost as effective as a full round nose.

Complete "fairing" (filling up) of the space between the back of the tractor cab and the nose of the trailer (see Fig. 9) gives very perceptible improvement. Present design does not permit this, although future design probably will. It was found that by moving the nose of the trailer as close to the back of the cab as practical, power-stealing wind drag was diminished. Removing the spare tire, landing gear wheels, and even crossmembers from underneath the trailer body made very little difference in air drag.

Application of a "Beaver Tail" (see Fig. 10) reduced the drag by 12%, but the extra length makes this impractical. Rounding front corners and roof, and using a conventional tractor showed a reduction

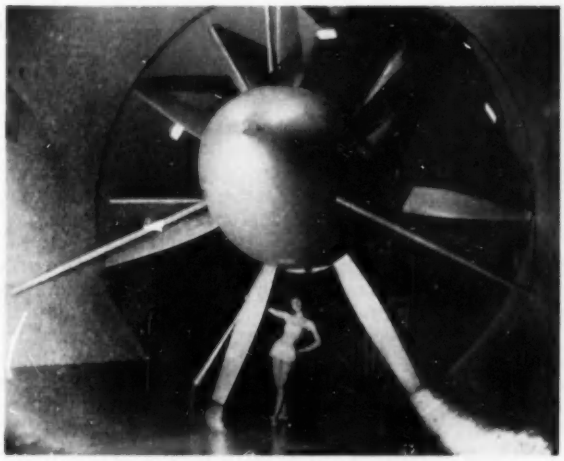


Fig. 7—This wind tunnel tests one-sixth scale model trucks with wind speeds up to 150 mph. It's an important tool in evaluating aerodynamic design of tractor-trailer combinations

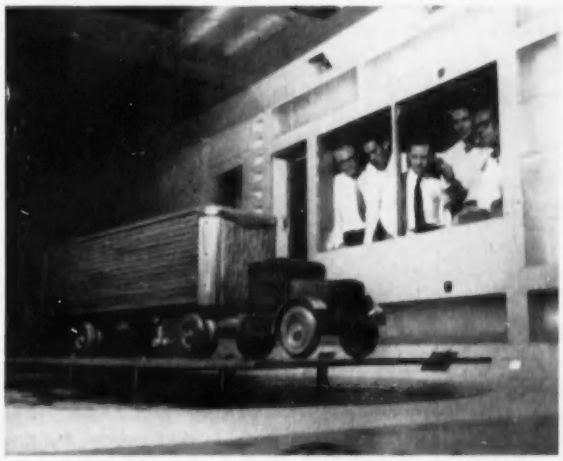


Fig. 8—Wind tunnel tests show that rounding trailer corners cuts drag by 24½% at 50 mph

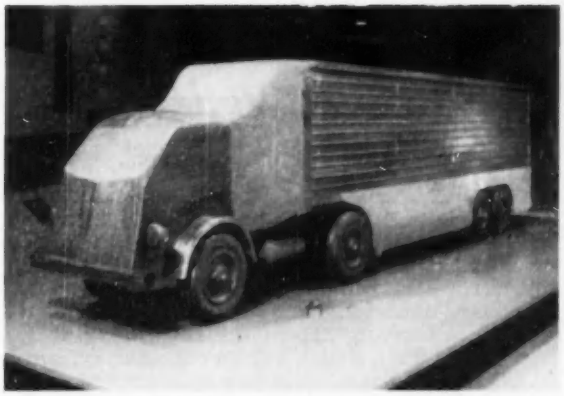


Fig. 9—Filling in the space between the back of the tractor and the front of the trailer helps cut wind resistance

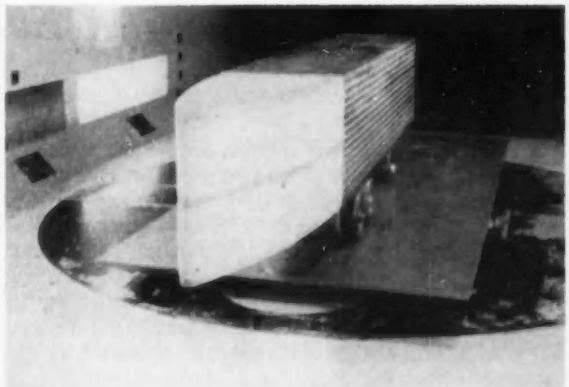


Fig. 10—This streamlined appendage on the rear of the trailer cuts drag 12%, wind tunnel studies showed

in air drag of 42%. The same combination using a cab-over-engine tractor showed a reduction of only 21%. The drag of all tractor-trailers increases materially in a crosswind. The drag increases about 28% at a 10-deg angle for both conventional and COE tractors in combination with a trailer, whereas the West Coast type tractor and the same trailer produces 70% increase in drag at 10 deg. A well streamlined and yet practical tractor-trailer combination should show saving of at least half of the horsepower consumed by present day models. This will become even more important as road speeds increase. We can foresee much greater attention being given to the factor of streamlining by the manufacturers of heavy-duty equipment for over-the-road operations.

5. Tires: Prospects Bright for Big Advances

A few years back, tests on tubeless passenger car tires did not prove out so well. Current developments show tubeless tires in both passenger car and truck size are proving practical, and eventually there will be savings which will include weight, longer lasting inflation, less flats, and fewer slow leaks. Tubeless truck tires with synthetic cords is the newest step for a longer life and safer tire. (See Fig. 11.) The use of better carbon black has produced 15% increase in tread wear since 1940. Still further improved carbon black in the future should increase tread wear by 15% or more.

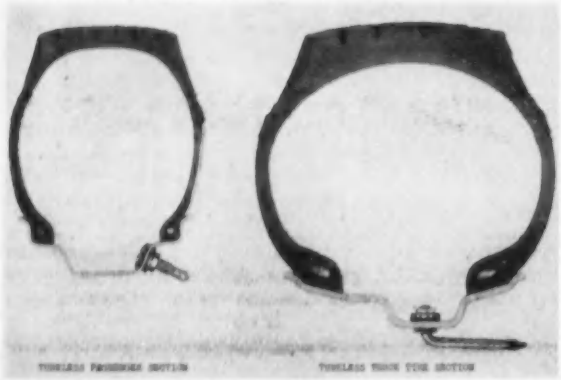


Fig. 11—Tubeless truck tires, as shown at right, achieve the same gains as the tubeless tire for passenger cars (at left)

Evolution of the deep tread tires is interesting. It started quite some years back as a slow speed start-stop operation tire, and it was thought that this deep tread would never be practical for high speed work because of heat build-up and not being able to dissipate the heat. This has been overcome recently, and so-called extra tread tires are in relatively common use. Actual tests show that in normal over-the-road service, a standard tire will give approximately 60,000 miles on the original tread, whereas the extra tread tire will produce 90,000 to 95,000 miles, and the operator has a better carcass in recapping.

Because of the nominal increase in price of the extra tread tire, they will come into greater use, not only in highway work but in metropolitan operations. This will result because of higher resistance to abrasion and cuts, and some resistance to puncture and safer driving with longer tread wear.

In the tire of the future, tire "squeal" on curves and corners will be eliminated. The future tire will be well balanced so as to no longer adversely affect steering geometry.

Load space, is so important to truck operators dealing in low density loads, they will have available to them smaller tires which will still have sufficient load-carrying capacity for use on long distance tractor-trailer equipment. This will promote safety to a certain extent by lowering the center of gravity.

6. Maintaining and Servicing Equipment: Automation on the Way

Automation will come into its own in work simplification. Push button control devices will be in the modern automotive repair shop in the not too distant future. Semi-automatic hoist equipment will provide ready accessibility to all parts of the chassis. Still more of the human element will be removed from engine analysis. Mechanical washing equipment, some of which has already put in its appearance, will largely eliminate manual work under unfavorable working conditions. Lubrication and oil changing will be further simplified, both by the lubrication equipment manufacturer and the truck design engineer. All of this will promote a smooth, straight line flow of work.

Mechanical tools for removing and remounting tires will take the place of manual equipment plus some air operated tools that exist today. The need for assimilating loaded conditions in testing an engine in the shop will be simplified as compared with the chassis dynamometer as it exists now. This will be a large forward step in the shop being able to turn out an engine that will go out and perform in actual highway use. The use of improved engine analyzing equipment will be a boon as far as driving personnel is concerned.

7. *Fuels and Lubricants: Look Ahead to Gas Turbine*

The three common engine fuels of today—gasoline, diesel, and propane—will soon be joined by a fourth, namely, gas turbine fuel.

Great progress has been made through technological advances in obtaining high octane gasolines which are resistant to detonation. Preignition and high octane requirement are two of the problems connected with the newer high compression gasoline engines. Preignition is the igniting of the fuel-air charge before its ignition by the spark. This may be caused by hot spark plugs and hot exhaust valves. Also, possibly by glowing particles of combustion chamber deposits.

The gasoline may contribute in that the lead salts formed during combustion catalyzed the oxidation of carbon, creating glowing particles having sufficient temperature to ignite the charge prematurely. There are several additives being used in gasolines, one of these chemical compounds contains phosphorus, and they are used to reduce the incidence of preignition and of spark plug fouling. It appears necessary to clean or replace spark plugs at lower mileage than formerly as a result of these deposits which appear to increase as compression ratio rises. Compression ratios in gasoline engines will continue to increase to the range of 8 to 1 to 10 to 1.

The gas turbine engine, weighing approximately one-eighth as much as similar horsepower gasoline or diesel engines, has proven experimentally practical in handling heavy highway loads. The big factor is fuel economy. It is not difficult to imagine that this factor will be overcome by engineers within the near future. High octane fuels are not required for gas turbines.

Furthermore, there will be a change in lubricants, since cylinder wall surfaces will be eliminated in favor of bearing lubrication. Therefore, lubricating oil requirements will be drastically altered.

These items assume considerable importance when it is noted that over recent years the petroleum industry has been investing four hundred million dollars per year in modern refining equipment to supply modern lubricants and high octane gasolines. Rapid industry-wide conversion to turbine-powered cars and trucks will make a great deal of this equipment obsolete long before the end of its useful life.

While advances are being made in horsepower output in gasoline engines, diesel engine engineers are not standing idly by. Exhaust powered superchargers will play a prominent part in increasing the efficiency and horsepower output of diesel engines.

Propane, better described by the term "liquid petroleum gas," has gained favor in bus operation, and will probably continue to grow in this field. One of the reasons is clean burning with very little exhaust odors. Its use in heavy-duty trucks will continue to be somewhat limited to certain sections of the country where supply and favorable state tax situations apply.

8. *Trailer on Flat-Car Service: Technique Is Spreading*

The above, sometimes known as "Piggy-Back," is the procedure of loading semi-trailers on railroad flat-cars and moving them to destination and usually returning the trailers in the same manner. This practice is not new and has been used by several of the rail lines over a number of years. Reports by one of the Midwestern railroads and the fact that one of the Eastern rail lines has expressed interest to the Interstate Commerce Commission as regards handling trailers for various types of carriers are strong indications that the operation is or can be profitable to the railroads.

Undoubtedly, this procedure will have a place in the future of nation-wide transportation; however, it will be limited largely to "line haul" operations. In other words, drop shipments would not be practical. It can be foreseen that this type of service will be offered in the not too distant future to all types of carriers and when it is, it will offer some contribution to the economy of the nation as far as transportation is concerned.

Conclusions

The foregoing deals largely with phases of the subject of future trends in automotive transportation and maintenance which are familiar to the author. Additional sources of power and the application and development of power shows the way to a brighter future in the field of transportation within the next 25 years. There are many parts of this whole subject that could not be treated in this article, and their omission does not in any way detract from their importance.

For assistance in supplying information and data that was most helpful, the writer wishes to give credit to the following: J. J. Black, vice president, Trailmobile Co.; D. B. Brenz, Products Application Dept., Shell Oil Co.; T. A. Robertson, tire engineer, Firestone Tire & Rubber Co.; R. C. Wallace, executive engineer, Diamond T Motor Car Co.; E. J. Welsh, fleet district manager, Ford Motor Co.

THE LOOK Ahead
1905 A GOLDEN ANNIVERSARY ARTICLE 1955

Diesel Engines . . . What Lies

THE 50 years growth of SAE closely parallels the life cycle of the diesel engine. Although the first successful diesel engine appeared in 1898, the commercial acceptability of the diesel began just 50 years ago. The first attempt of Rudolph Diesel to build a perfect heat engine, illustrated by Fig. 1, is a sprawling giant of 20 hp compared to the recent concentrated energy package in midget form, the Napier Nomad of 3200 hp, shown in Fig. 2. These monuments represent the milestones of progress in 50 years of diesel engine evolution.

It has been said that no man is civilized or mentally adult until he realizes that the past, the present, and the future are indivisible. The course of any venture is subject to the searching questions:

1. Where have we been?
2. Where are we now?
3. In what direction are we going?

On this philosophy, the past is used to explain the present and the present to project a speculation of the future.

The diesel engine was slow to win favor of the power-using public. It was also slow to win recognition in the automotive world. ". . . it is difficult to realize that the first reference to the diesel engine, in SAE records, reads as follows: 'That engine has not proved a very practical engine; no particular use, I think, for motor cars. But it has a high thermal efficiency and is perhaps practically about the limit which we may ever expect to reach with oil as a fuel.' That was in 1909 and apparently no more notice was taken of the diesel until 1913 when it was mentioned in a paper on 'Kerosene Engines'."[1]

[1] SAE Journal, Volume 37, July, 1953, pp. 22–23.

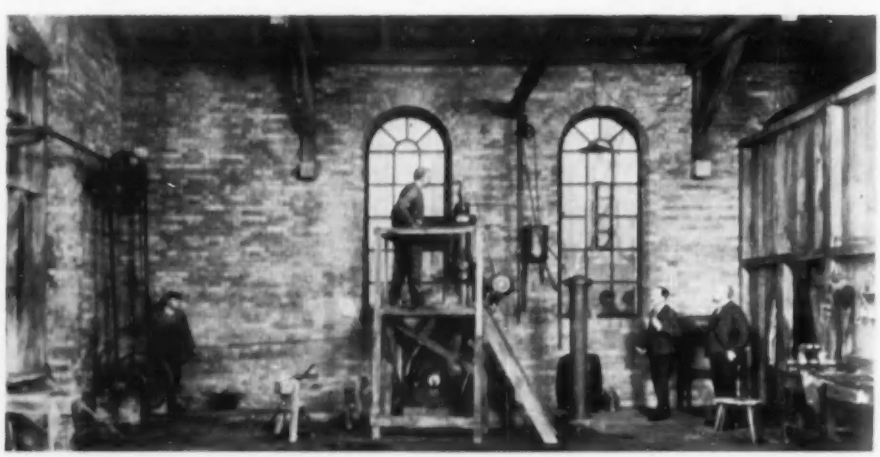


Fig. 1—Testing the perfect cycle engine at MAN by Dr. Diesel (Courtesy MAN—Augsburg)

Ahead

by C. G. A. Rosen

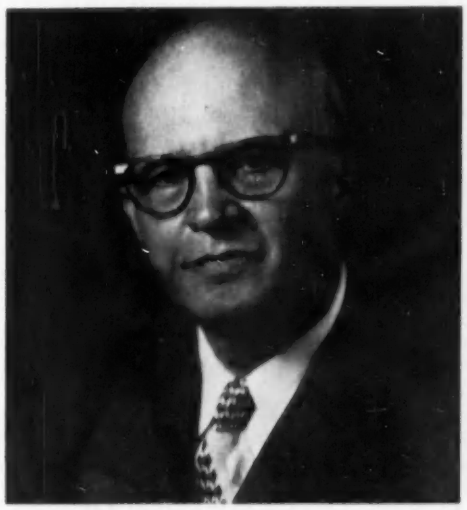
Three years later, in 1916, SAE Council gave consideration to gathering and disseminating technical data because it was thought that the diesel might in time become important. This was done, as the record states: "for the purpose of developing a better diesel engine." After some discussion of the advantages and disadvantages of the diesel engine, the opinion was expressed that: "It is not impossible that the diesel engine will eventually be the universal internal combustion power producer."

Threat of a gasoline shortage in 1917 and 1918 focused attention on the economy of the engine and technical papers began to appear. In 1930, after the SAE Diesel Activity was formed, a Diesel Engine Division was set up by the General Standards Committee. The technical committee work on diesel engines began and is still proceeding actively in the engine committee of the SAE Technical Board. Since then the topic has received its full share of attention on all SAE programs.

Lusty Future Seen for Diesel

At the time of the "Fifty Years of Diesel Engines" celebration by Maschinenfabrik, Augsburg-Nurenberg at Augsburg, Germany in January, 1948, these words were recorded: "We are living in a period of the greatest historical metamorphosis, bringing the comprehensions, conditions and events of the 19th Century into far remoteness. In this remarkable century the diesel engine is the leading heat engine, spreading and improving irresistibly. MAN is convinced that even after another 50 years the world will still remember the diesel engine as a great technical achievement, even if new kinds of heat engines should be invented and new sources of power

SAE Golden Anniversary Author



C. G. A. Rosen

C. G. A. Rosen, consulting engineer for the Caterpillar Tractor Co. in Peoria, Ill., was born in San Francisco, July 14, 1891. He attended Cogswell Polytechnic Junior College and later received the bachelor of science and Mechanical engineering degrees from the University of California.

From 1915 to 1922 Rosen served with the Dow Pump and Diesel Engine Co., advancing from draftsman to chief engineer. In 1923 he joined the Pacific Diesel Engine Co. as chief engineer. From 1928 to the present, he has been associated with the Caterpillar Tractor Co., where he has continued in diesel development work.

Rosen is the holder of many patents on diesel engine refinements. He at one time conducted a course in diesel engines for the University of California Extension School and prepared texts for diesel correspondence courses. From 1951 until the present, he has been a member of the Vehicles Panel Committee, Research and Development board of the U. S. Office of Defense.

He has been elected 1955 SAE President, having a long and active history in the Society. He served on the SAE council in 1943–1944 and was vice-president representing the Diesel Engine Engineering Activity in 1940. His committee work has included the Clarkson and Horning Award Committees, Publication Committee, Fuels and Lubricants Activity Committee, War Engineering Board, and the War Engineering Board's Torsional Vibration Project Committee, of which he was chairman.

disclosed because this engine has influenced an era, during which the power of our scientific and technical knowledge was revealed in such an extraordinary manner."

It is interesting to note how this prophesy of the future is held in general agreement by the majority of diesel engine designers in this country. There are some differences of opinion as to the time of appearance of other types of heat engines or new sources of power, but there is general agreement with one engineer as he states: "We have engines designed in 1925, practically 30 years ago, still in production. Apparently when a piece of machinery is well designed it has a very long life. Therefore, engines as we know them, but with refinements, are likely to live well into the future 50 year period."

Another diesel engineer predicts the future with some caution, as he states: "The life of internal combustion prime movers is closely tied to a supply of fuel of finite amount: no more fossil fuels—no more diesels."

Another diesel man has positive convictions when he states: "I am thoroughly convinced that possibly the next new era of power will be the gas turbine." However, he adds: "It is my firm belief that it will take longer to develop the gas turbine than we have taken on the diesel engine to arrive at the same state of perfection that we are now in on the diesel."

These are interesting speculations and one can heartily agree with the sentiment of Arthur Pope: "I wish I could be here 50 years hence to see how far we miss the mark." This could all be too true as in 1931 I read a paper before SAE wherein I was thoroughly convinced from my background in big engines that the diesel cycle was limited to speeds of 1000 rpm.

In planning a speculation of the future one is impelled to agree with the remarks of Professor Broeze. "As long as petroleum is available, its fuels will dominate the automotive picture, and even a very long forecast should not fail to present an overall picture with gasoline and diesel engines and turbine drives. It would seem that the trend toward diesel engines will continue to develop the more so, as lead is likely to prove a bottleneck before petroleum."[2]

Five Factors Shape the Future

What are the development trends which attract our attention, and what are the influences which are pertinent to these trends? In general, they can be stated as:

1. The cost and availability of fuel.
2. The demand for increased performance.
3. The urge for higher horsepower per cubic inch of piston displacement.
4. The achievement of maximum portability per brake horsepower.
5. The lowering of maintenance cost and the increase of engine life between overhauls.

Fuel Economics

The influence of fuel is a pertinent consideration in the development of any power plant for whatever purpose. An attempt to establish the trends of

[2] Prof. J. J. Broeze, "Automobiles and Petroleum, Past, Present and Future," Institution of Mechanical Engineers, June 16, 1954.

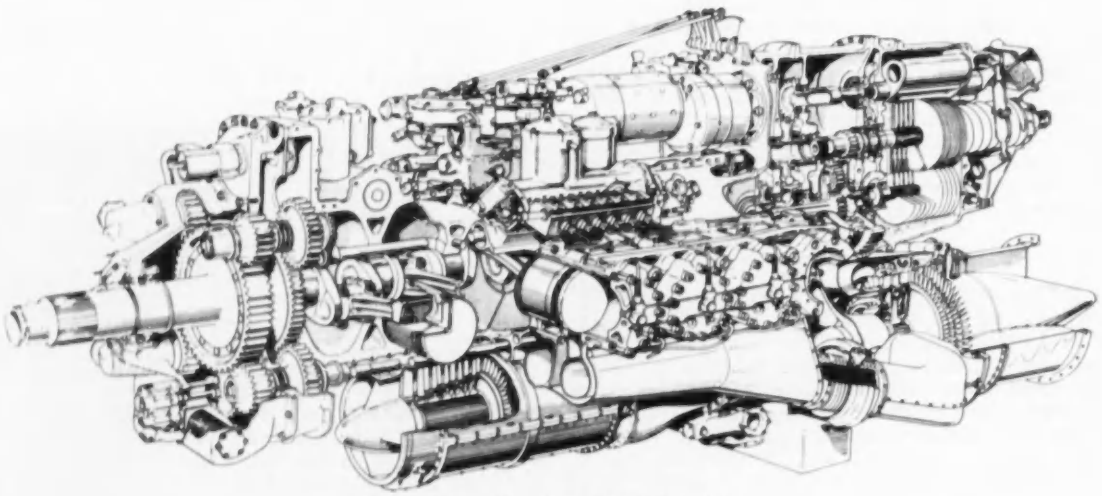


Fig. 2—Napier Nomad aircraft diesel engine

The Challenge Ahead in Diesel Engineering

The diesel engine's progress from here on in will depend largely on solution of currently bothersome problems, says author Rosen. Here are some of them which he points up in this article:

- **To come up with a satisfactory explanation for self-ignition of fuels.**
- **To perfect diesel combustion so as to minimize noise, smoke, and odor.**
- **To find ways of speeding up diesel combustion without creating shock loading.**
- **To develop new lubricants with greater oxidation resistance.**
- **To evolve component parts—particularly rings, pistons, and bearings—and materials for them to permit higher outputs per cubic inch of displacement.**
- **To find ways to load and scavenge air properly to improve the charge to the cylinder.**
- **To simplify engine design.**

power plants must perforce first find the fuel to be used as a source of energy. The type of fuel at present made available in any locality is determined either by the performance characteristics required of the engines being served, or the ability of such engines to consume general fuels, and by the cost of the fuel.

The entire refinery situation has changed materially within the last several years. Some twenty years ago it was customary to obtain from a barrel of crude by means of straight run refining methods —20% gas and gasoline, 40% distillate fuel and 40% residual fuel. With time, the automotive population has grown so rapidly that the demand for gasoline has risen to such an extent that the refinery methods have been forced to change to achieve a higher yield of the proportion of gasoline from a barrel of crude. The demand for residual fuels has been constantly dropping off because of the evolution in railroad locomotives from steam to diesel.

Refinery methods and techniques have advanced to the point of re-cycling residual fuel to produce more gasoline and more distillate, leaving a present possible yield from a barrel of crude of 50% gas and gasoline, 44% distillate fuel, 3% residual fuel and 3% coke. The exact proportions, however, of the terminal products are eventually determined by the economics of refining in any given locality with reference to current demands. Premium fuels in the kerosene range have shown a very sharp rise in price since 1940. Diesel fuel No. 2 has also had a consistent rise, whereas, the heavier fuels have not had the same increment of increase over this period. The sensitive appetite of some engines in specific services has furthered the demands for the kerosene type of diesel fuel. In 1940 there was a goodly quantity of a fuel called a No. 3 distillate at a price a little higher than commercial fuel oil. Today No. 2 diesel fuel is sold to the railroads at a little over ten cents a gallon. It is expected to rise to still higher values in the future.

The question can naturally be asked: How far will the commercial user tolerate this trend in rising fuel cost? In the diesel range there is reason to believe that a fuel between the No. 2 diesel and the commercial fuel oil will ultimately find broader acceptance in vehicle power plants.

This is predicated on the fact that the railroads are the major users of diesel fuels. The railroads will foster a reduction of fuel costs by relaxing the fuel specification requirements. The availability of larger quantities of residual fuels will result in deeper cracking to reduce the residual fuel inventory, which in turn, increases the cracked distillate inventory. The availability of cracked distillate in the No. 2 burner fuel range presents a marketing problem where such fuels may be from ½ to 1½¢ less than straight-run, high cetane diesel fuel.

It is anticipated by some in the petroleum industry that the railroads will set the stage for burning a lower cost fuel in automotive type diesel engines. Such a trend should interest the high-speed diesel

engine builders in developing fuel systems which will successfully burn fuels of lower cost in the cracked distillate category. If diesel fuels create more complicated technology in petroleum refining, it can be expected that diesel fuels will rise to still higher costs. The more readily producible and marketable fuels will be the fuels in the lower cost bracket.

Chemistry to the Rescue

The development of detergent-type lubricating oils has largely offset the bug-a-boo of high sulfur fuel wear due to corrosion. The action of detergents has improved maintenance by the prevention of deposit formation in the combustion chamber envelope. The action of anti-oxidants has minimized the detrimental influence of crankcase diluents. The hard starting problem with low cetane fuels has been greatly relieved by the use of fuel additives as well as by ether and chemical assists and devices for contributing to the initial firing of fuel.

The one pertinent fuel problem still remaining is that of low temperature flow as influenced by pour point and cloud under cold weather operation. These factors present restrictive specifications on diesel fuels. There is much need for cooperation by the petroleum industry and engine manufacturer in the solution of this problem so as to permit the broader use of distillate type fuels over a wide geographic range of temperatures.

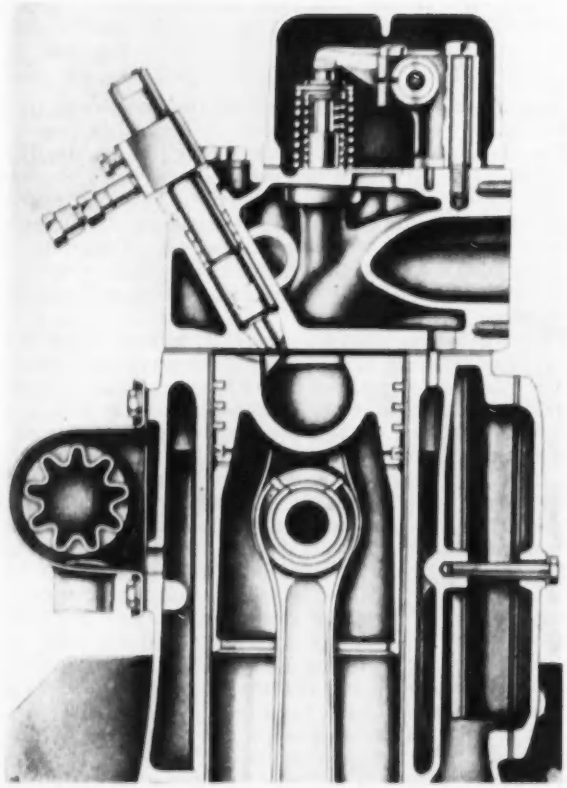


Fig. 3—MAN "Whisper" engine (Automobile Engineer—April, 1954)

During the past 30 years much has been learned with regard to the specific properties of diesel fuels, which cause ignition delay and which adversely affect the rate of pressure increase within the cylinder. Combustion chamber designs and other dependent factors affect smoothness of operation. Compression ratio, one of these factors, furnishes a means for rating the ignition quality of a fuel by the cetane number method.

No real satisfactory explanation, however, has been given for self-ignition of fuels. The property cetane is often considered the only variable involved. However, cetane number increases as the boiling temperature of the fuel increases. Volatility alone cannot be the determining factor for initiating combustion. A number of theories still prevail with respect to the factors attributable to self-ignition. Some believe that self-ignition is due to a temperature rise originating from exothermic chemical reactions. Boerlage and Broeze believed that cracking takes place in the fuel molecule which achieves pre-ignition temperatures. Tausz and Egerton believe in the decomposition of unstable peroxides which are formed near ignition temperatures. In other quarters there is a feeling that ignition takes place directly from the liquid phase because the self-ignition temperature is lower in the liquid phase than in the vapor phase.

Other chemists believe that no ignition can take place in the liquid phase and that a vapor phase must be present before ignition can occur. Some interesting experiments by Professor S. J. Davies[3] indicate that ignition occurs before 10% of the droplet has been vaporized. After ignition there appears to be a very critical increase in the vaporization rate attributable to the absorption by the droplet of heat released by cracking. This cracking is revealed by the presence of free carbon. The heat released by cracking is transferred to the droplet and the burning of the carbon is completed with great rapidity.

This theory by Davies seems to find verification in the new MAN development called the "Whisper" engine. It also finds application to the precombustion chamber engine. The MAN engine is claimed to have a new kind of combustion system which according to Professor Pischinger is "likely to revolutionize the automotive diesel field." A cross-section of this engine is shown in Fig. 3, and a description of its operation has been given by Professor Paul Schweitzer as follows: "The MAN combustion system is an open chamber engine fitted with a masked inlet valve and the piston is permitted to create considerable squish at the end of the compression stroke.

"The combustion process is then as follows: As the piston approaches top center on the compression stroke, a vigorous air swirl sweeps the piston cavity. Two jets penetrate into this and they form a little cloud before they strike the hot surface of the piston which is held between 400 to 750 F by the control of

[3] Prof. S. J. Davies, "Combustion in Compression-Ignition Oil Engines," The Chartered Mechanical Engineer, Volume 1, January, 1954, pp. 24–36.

the lubricating oil sprayed under it. This could act as the initiator of ignition much as the fuel oil factor in a dual-fuel engine. In the meanwhile the balance of the fuel is smeared on the semi-spherical combustion chamber wall and becomes vaporized at a controlled rate. As the fuel is vaporized it ignites and burns in a narrow layer near the wall, then more fuel strikes the wall and the burning continues. The flame front never has a chance to develop and a large amount of fuel never has a chance to crack at any one time."

This engine improves the old surface-ignition type of combustion which was prevalent some 35 to 40 years ago in this country. The hot bulb engine did not prove generally successful; but here in the MAN engine we have the application of new combustion knowledge superseding old ignorance and achieving, by application of advanced concepts, a rather revolutionary type of combustion system. Many other old ideas are due for new overhaul before the diesel becomes extinct.

The future bids well to improve this situation and provide us with means of obtaining quiet combustion with high torque characteristics and low speed smoothness as well as economy.

Diesel combustion is still pursued by three annoyances, noise, smoke and odor. These problems must of necessity be solved so that the diesel may achieve its full utility in automotive service.

The diesel engine has a much cleaner combustion chamber than the spark-ignition engine. This points to the importance of working whenever possible with excess air. The diesel engine in general thrives on excess air. This is further reason for utilizing supercharging. **Future developments in diesel engines will tend toward the combination of high supercharge with a proper air excess of approximately 100% or so in order to obtain insensitivity to mixing difficulties.**

This also supports the trend toward compound engines where the excess air at high supercharge with lean mixture ratios is not lost, but is ultimately picked up in the turbine. This, combined with the fuller utilization of the exhaust gas energy, will lend impetus to diesel heat generator-turbine combinations as characterized in Fig. 4.

The more one experiences supercharging in compression-ignition engines, the more attractive it becomes. Differences in fuel qualities tend to diminish and efficiencies to increase. Too often, however, the popular idea among diesel engine designers is to give extravagant emphasis to bmep without due regard to mixture formation.

The most significant difference between a carburetor engine and a diesel engine is in the nature of the charge itself. The carburetor prepares a ratio of air to fuel external of the engine cylinder and the process of completing a homogeneous charge of air and fuel vapor within the cylinder continues during the compression stroke. Mixture formation, therefore, in the spark-ignition engine has practically two complete strokes in which the air and fuel can be subjected to means providing a homogeneous charge. For this reason a spark-ignition engine can operate on an air/fuel ratio of about 14.5:1 irrespective of load.

In the diesel engine there is a heterogeneous or a stratified charge. The mixture ratio varies from

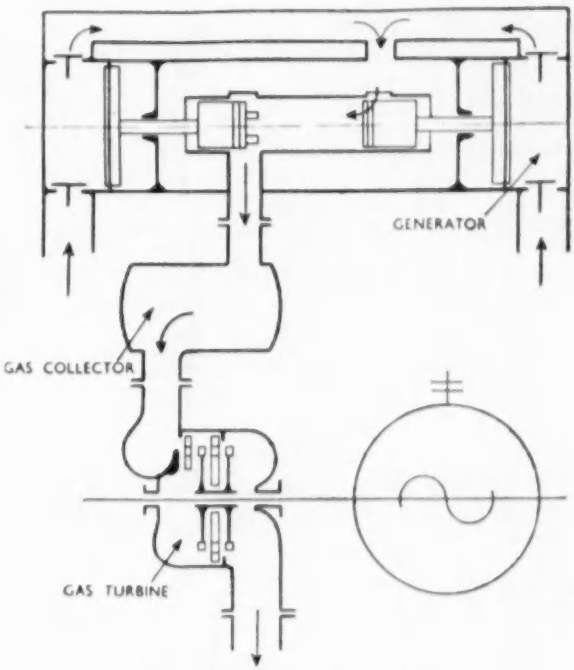


Fig. 4—Compound diesel powerplant

point to point in the combustion chamber, from very lean to very rich. A 2000 rpm engine has about 0.003 sec, or around 20 deg of crankangle in which to complete the mixture formation suitable for combustion conditions. With such a short period of time, by comparison with a spark-ignition engine, it is practically undesirable to operate at continuous load ratings at comparable air/fuel ratios with the expectation of satisfactory service results. The over-all air/fuel ratio in a diesel engine can vary from 18:1 at full load and may be beyond 100:1 at no load.

The larger MAN high output four-cycle supercharged diesel engine distinctly operates at high excess-air ratios. The Sigma free piston engine as used in the compound cycle, operates at air/fuel ratios as high as 40:1. The compound engine provides the opportunity for recapturing most of the energy put into the air even at high supercharged boosts, as expansion is completed to low levels in the gas turbine portion of the compound cycle. In the normal supercharged diesel engine—where rich mixture ratios are attempted under continuous operating service conditions with high boost air-charge temperatures—high heat transfer rates through pistons, heads, and cylinder walls are demanded to prevent over-stressing of critical engine parts resulting from excessive heating due to after-burning during the expansion stroke. There is urgent need

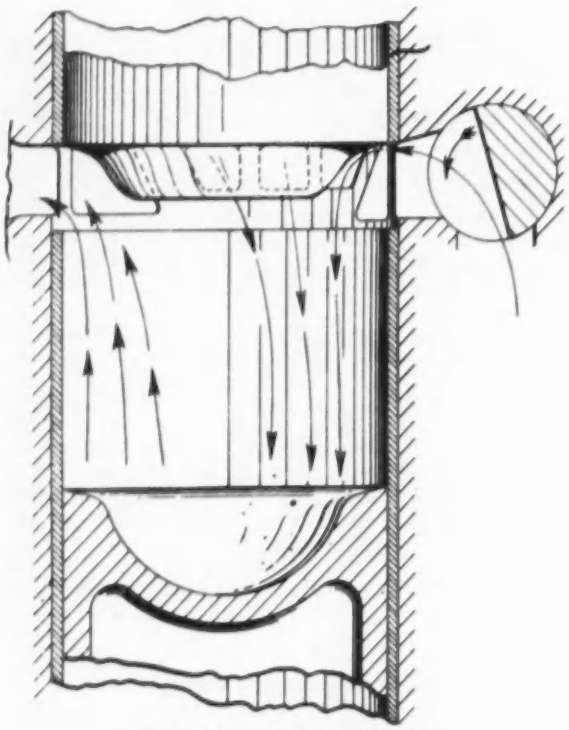


Fig. 5—Sleeve valve two-cycle engine

for developing methods for speeding up combustion without creating shock loading.

To achieve longer life in service higher air/fuel ratios are desired which can be economically provided by the efficient application of turbo-supercharging. The application of the turbo-blower to vehicle type powerplants has proved somewhat difficult at times due to the lag between the turbine and the blower during acceleration. This lag can be considerably shortened by the use of variable-area nozzles in the gas turbine, which permit maintaining sufficiently high compressor speeds to justify sufficient air delivery to accommodate the incremental increase in fuel during acceleration.

The demand for increased performance will promote the use of turbo-supercharging on four-cycle engines at increasing pressure ratios. This will be followed by similar treatment of two-cycle engines. In the immediate future, a 100% increase in output over atmospherically-aspirated engines is readily assured in four-cycle designs. With problems solved at this level of performance there is no reason why the trend will not rise to a multiple of this value, with time.

Possibilities prevail for similar advantages in two-cycle turbo-supercharging by increases from 35 to 50% in output. Higher increases will be made available by the maintenance of the cylinder air-charge temperatures at reasonably low levels with a proper balance of excess air. The possibilities of a loop-scavenged sleeve valve engine, Fig. 5, appear promising for still higher supercharging of two-cycle engines. Cylinder lubrication and port clogging problems are minimized by the sleeve valve design. These increased performances should be accompanied by corresponding gains in fuel economy and in lower proportionate heat losses to the combustion chamber envelope.

Higher specific powers will demand new lubricant developments with greater oxidation resistance in order to permit higher rated engines to live at reasonable maintenance cost with acceptable hours between overhauls.

In general, to achieve more satisfactory commercial developments economically feasible in lighter weights or smaller space, or higher outputs per cu in. of piston displacement, requires the development and intensive evolution of component parts. The principal bottlenecks are pistons, rings and bearings. The development of suitable materials for these parts which will function under the heat-flows experienced at high output and higher speeds, must be supplemented with improved knowledge on combustion and injection characteristics. There is a vast field for exploration in proper loading and scavenging of air to improve the charge to the cylinder. There is need for better mixture formations to promote the rapidity of combustion and completion of burning necessary for the efficient utilization of fuel. Above all, there is a great need for simplicity of design.

As a general rule, in all modern power plant projects there has been much effort in achieving gadgetry and adding extraneous accessories which are of no essential value in improving the thermodynamic performance of the power plant. The friction horsepower has been moving upward because of accessories and gadgetry.

Future power plants must be concerned with improvement of cyclic efficiency and the proper allocation of temperature levels in relation to the capacity of parts to furnish adequate heat transfer. A caution is well expressed by Merrill Bennett: "The economic ramifications of prophesying future trends in diesel development must be concerned with rising labor costs which might well prove to be a potent factor in shaping the future of the diesel. The prime-movers of the future must lend themselves to inexpensive construction and maintenance from the labor standpoint. This factor can possibly operate to reduce the life span of the reciprocating engine."

This article has concerned itself with the diesel engine and its future. Undoubtedly the diesel engine will meet with the gas turbine as a worthy competitor, but that is another story. With time, atomic power may present its influence on the selection of power plants. Far out in the future, solar energy may still be a potent contender for acceptance.

In the meantime it is our job as diesel designers to consider that diesel progress in the years that lie ahead, must come through increasingly better solutions to the current problems which beset us. The imaginative designer of the future may well initiate radically different approaches to the fundamental problems of diesel power.

The First 100 Years of Aircraft Powerplants

by P. B. Taylor

• In the next phase of aircraft powerplant development, powerplants will take over the landing and take-off functions.

• This will involve a radical change in aircraft configuration from that prevailing during the piston engine and gas turbine phases of powerplant development.

• The next phase will start about 1960 with the application of jet lift to aircraft for take-off and landing.

COMING JETS:

They'll Take On New Jobs

Rudimentary experiments on control of landing and take-off forces have been recently publicized. This technique immediately produces drastic changes in the aircraft which reflect on the powerplant. It is hard to decide which comes first, but the determination is important only in setting up a description of the vehicle. As take-off and landing are accomplished by direct lift from the powerplant, the wings can be reduced in size and form to the surface required for high speed flight at say 500 mph at or near sea level. This immediately makes possible what might be called an aerodynamic fuselage of Buck Rogers configuration.

The thin wings with wing flaps for landing will disappear in favor of minor extensions of the fuselage. The landing gear, having given up its function of resisting heavy shock landings and of facilitating high speed roll and deceleration on the airport, will be reduced to elementary stubs, retractable or not, to take the load of the airplane landing from a gentel vertical descent.

With these two changes, the airplane can be de-

signed with far greater structural integrity, since the compromise between wing rigidity and thinness has disappeared and the problem of retraction and stowage of a bulky and heavy landing gear in a small wing or fuselage has been eliminated. Powerplants for such an airplane will be the turbojet type. Direct lift take-off thrust will be supplied by main engines fitted with a retractable set of vanes to convert rearward thrust to vertical thrust supplemented by auxiliary engines specialized for the take-off and landing function. Such engines can be made within present knowledge for about 1/10 pound weight per pound of thrust.

Less Weight, Less Drag

The direct lift technique will require a relatively small amount of additional fuel for take-off and landing to compensate for the difference in efficiency of the new and old procedures. The net result of all changes will be a large saving in weight and a great reduction in drag at high speed. It is impossible to apportion the weight saving other than by a specific airplane design; but additional gasoline can be provided to supply large propulsive engines operating over increased ranges and speeds.

Such an airplane will be appropriate for all types in which speed is paramount. The transport version will be able to fly continuously at Mach 2.5 and at the same time duplicate the performance of the best modern transport in terms of payload and range. It is too early to know the limits of this type of airplane. Incidentally, this airplane would appear to solve the air terminal problem in relation to large centers of population, except for the noise developed by the engines at take-off and landing. Reduction of noise and/or increase in the noise tolerance of neighbors I leave for future invention.

The use of fuels of greater energy content applied to present and future powerplants would, of course, reduce the fuel load carried by any airplane for a given mission. Such a development may take on new significance at any time.

PISTON ENGINE: Reaching Top of Its Potential

These future powerplants will influence future aircraft configurations just as they have done since the beginning of powered flight. The success of the Wright brothers at Kitty Hawk in 1903 was to a large extent made possible by a most ingenious internal combustion engine of irregular configuration which produced 18 hp and weighed 148 lb. The brothers designed the engine themselves and built it in less than three months, an achievement which has probably since then never been equalled.

In these early days the aerodynamic problems connected with aircraft powerplants received no attention and were of no consequence. That's because airplane forward speed was less than 50 mph and wing lift rather than airplane drag was the important factor. The drag problem did not become important until 25 years later when the relocation of radiators on water-cooled engines and the use of the Townend ring and NACA cowl on aircooled engines resulted in a surprisingly large increase in speed on then current aircraft. Larger engines running at higher rpm, developed soon after this discovery, made reduction gearing to the propeller necessary.

The introduction of wing flaps used in landing and take-off broadened the flight speed range, which then required adjustable-pitch propellers to permit the engine to develop sufficient thrust for take-off and single-engine flight operation. Each of these developments brought the powerplant into more intimate relationship with the airplane in which it was installed. **This trend has continued, forcing airplane aerodynamics and airplane powerplants roughly to keep pace with each other.** With the advent of the gas turbine, these two elements become almost one and the same problem, as will be discussed later.

Piston Engine Led Pack

The four-stroke otto cycle engine took an early lead in powerplant development for aircraft and all early attempts to displace it with other forms met with failure for a variety of reasons. The steam powerplant for aircraft propulsion was not successful because of the complication and weight of the non-condensing boiler with its large water content. This boiler was used because of the impracticability of condensers capable of establishing a reasonable vacuum without a large heat dissipating unit of high weight and drag.

In later years, when engineering progress had brought the steam concept within the realm of possibility, the gasoline engine had become so firmly entrenched and so highly developed that the effort required to displace it could not obtain financial support.

The two-stroke cycle in the early days was not sufficiently well developed to compete with the four-stroke cycle, and by the time it was ready the four-stroke was miles ahead.

Several attempts were made to introduce the diesel cycle, but all came to naught because inherently this cycle has a higher weight per horsepower of output, and with the development and availability of high octane gasoline, the fuel consumption of the otto cycle was made closely to approach that of the diesel. Another attempt has been made since World War II in which the diesel has been compounded

P. B. Taylor, partner in the firm of Sanderson & Porter, has carried out many engineering activities for the aircraft industry in that connection.

Taylor gained several years of machine shop experience before joining Wright Aeronautical Corp. in 1922 as a test engineer. He worked for Wright until 1945, advancing to the position of chief engineer and finally general manager before resigning. In August of that year he was engaged by Pan American World Airways to make a world survey of gas turbine engines, with special attention to their importance in commercial applications. This work led to the importation of the Rolls-Royce Nene turbojet engine and its quantity manufacture for the U. S. Navy by Pratt & Whitney Aircraft. In 1946 he became a partner in Sanderson & Porter, consulting engineers.

P. B. Taylor

He was born in New York City in March, 1899 and attended elementary and high schools in Montclair, N. J. He is a mechanical engineering graduate of the Sheffield Scientific School, Yale University. He received his degree in 1920.

Taylor has participated in government activities as chairman of the Propulsive Systems Panel and as chairman of the Aeronautics Committee of the Research and Development Board. He was formerly a member of the Powerplants Committee of the National Advisory Committee for Aeronautics, and of the Scientific Advisory Board of the U. S. Air Force. He is presently vice chairman of the Technical Advisory Panel on Aeronautics to the Assistant Secretary of Defense for Research and Development.

He served as SAE vice-president representing Aircraft Engine Engineering in 1935. He has also been a member of the Montclair Society of Engineers, the Yale Engineering Association, the Institute of the Aeronautical Sciences, and the American Society of Mechanical Engineers.

with an axial-flow supercharger and an exhaust turbine. Although the engine gives good performance, it is doubtful that it will be used extensively.

The water-cooled gasoline engine itself lost its early lead and nearly became the victim of obsolescence as the extra weight, complication, drag, and vulnerability of its cooling system ran into keen competition from the direct aircooled radial engine which releases its heat at a higher and, therefore, more favorable temperature. With tight baffles and adjustable flap cowling, the aircooled radial forms a reasonably efficient aerodynamic element in an airplane of moderate speed.

The integral or attached mechanically driven supercharger, applied to nearly all leading engines by 1930, was a truly revolutionary development. Not only did it permit recuperation of engine performance at altitude, where power normally falls off, but it permitted engines to produce excess horsepower at take-off and climb. This development immediately set up a demand for better gasoline, since the knock quality became a limiting factor for engine power output.

Greater horsepower output derived from increased compression ratio, improved supercharger performance, and increased rpm, made possible through the use of these improved fuels in the same engine size, has been the guiding principle in the otto-cycle aircraft powerplant development—which has not yet completely run its course.

Engine Shape Adapted

As airplane speeds increased, many attempts were made to better adapt the engine configuration to the aircraft by decreasing frontal area, burying the engine in the wing, and other such moves. These took the form of V engines—two banks of six cylinders each; flat engines, two banks of six cylinders each, horizontally disposed; H engines, two flat en-

gines geared to a common shaft, usually vertically disposed; four-deep seven-bank radials and six-deep seven-bank radials; and many others. A few of these configurations were successful and are in use today.

A backward view of these developments would indicate (at least to the author) that in the aircraft current at the time, no great advantage was obtained from engine form other than to crowd more cylinders together to drive a single propeller. It was, however, found that flat engines were not flat and would not fit into wings for which they were originally designed, because the engine became taller and the wing thinner before the project was finished. Complicated and unsymmetrical arrangements of aircooled cylinders were difficult to cool evenly. The honors went to the simplest engine on which the most development work had been done. The one significant factor which emerged was the superior characteristics for large engines of a cylinder of about 6-in. diameter over all other sizes.

An important achievement was made in the adaptation of the exhaust-driven turbosupercharger to the reciprocating engine. This was introduced by the U. S. Army as early as 1920, but did not come into common use until the late 1930's. The device takes energy by means of a turbine from the hot gas of the engine exhaust, by means of which it drives a supercharger supplying air to the carburetor at pressure above ambient. A simple bypass valve in the exhaust duct controls the degree of supercharging under both sea level and altitude conditions.

As a further extension of this principle, the compound engine has been developed which puts the exhaust energy back into the engine crankshaft by means of gearing, resulting in substantial increase in power output with an accompanying decrease in specific fuel consumption. **The compound engine configuration seems to bring the four-stroke otto-cycle aircraft powerplant to its highest point of usefulness in modern aircraft.**

Such an engine derived from present models, since no new ones are likely to be developed, can be expected ultimately to achieve approximately 4500 hp at take-off, cruise at 2500 hp at 35,000 ft altitude, at less than 0.40 lb per hp-hr specific fuel consumption, at a weight of just under 1 lb per hp. This seems to be the limit of performance which the reciprocating engine is likely to reach in its remarkable advance over the past 50 years.

It is still the mainstay of our commercial transport system, but is fighting a rear guard action. Signs of the ascendency of other forms are all too evident. Although the old type will continue to be used in great quantity for a number of years, it will probably not remain as a type to the end of the century. Its days as a leader are definitely numbered and, in consequence, development has slowed down to a walk and few new engine developments have emerged in the past decade. **The year 1960 might see the end of piston engine development.**

With the development of the reciprocating engine to the point indicated above, Phase I of powerplant development can be considered to be completed. This phase has taken the art of flying from first flight to regular passenger routes over the Atlantic for planes carrying up to 100 people at speeds of up to 300 mph.

TURBOJET:

Brings New Engine-Plane Relationships

Phase II of aircraft powerplant development started with the introduction of the gas turbine jet powerplant by Dr. von Ohain of the German firm of Ernst Heinkel, A.G. in 1939, and Sir Frank Whittle in England in 1941. This powerplant by its nature must be intimately designed into the aircraft which it powers and the aircraft must be a high-speed vehicle. The propeller gas turbine, a derivative of the jet, is broader in its application, as will be discussed later.

The early embodiments of the turbojet were relatively simple, consisting of an intake, which was little more than an area to admit air, a centrifugal compressor of moderate efficiency, a group of combustion chambers in parallel, nozzle guide vanes, a turbine wheel, and a fixed exhaust nozzle. The entire unit was arranged with a simple mechanical fuel control system and, of course, an oil system and other features such as ignition plug, a starter, and fuel pumps. To a powerplant designer of the old school this seemed like a miracle of simplicity, but not for long.

As with the early reciprocating engine, the first marvel was that such a powerplant would sustain an airplane in flight. Of course, it was considered a gas-eater which gave the airplane no endurance possibilities. But speed was the engine's best friend because of the basic increase in propulsive efficiency with higher speeds. And since endurance was limited by high fuel consumption, the original embodiments were naturally directed toward short range fighter types where the speed advantage was paramount.

As soon as the shock of this new type powerplant was over, the airplane designer discovered that he had a lot of work to do. The conventional models were no longer suitable as many of the design features were no longer required, such as tail landing gear and space between powerplants and fuselage for propeller clearance. As the plane was moved

into the higher speed range by thin wings and removal of old restrictions, additional rewards in range as well as speed were realized. Changes took place in wings and tail, landing gear, fuselage, controls, powerplant locations, and even "name plate."

A new kind of design interrelation between powerplant and airplane appeared, in which the airplane design was concerned with external aerodynamics and powerplant design with internal aerodynamics, and the two were tied together at the air duct entrance and the discharge nozzle.

A vast amount of theoretical analysis was needed to understand this new interrelation, and original thinking was needed to make the most of the new possibilities. Neither is as yet complete, but much progress has been made and many new concepts have been developed and verified by wind tunnel and flight test.

Turbojet Becomes Complicated

As always, what was initially a simple powerplant became an assembly of sensitive interrelated parts, each of which had to be developed over years of research. Additional requirements were discovered such as de-icing of air intake, driving power for aircraft accessories, compressed air supply for the cabin and lately for blowing flaps, and a host of other items. The engine itself developed complication such as:

- Axial flow compressors with thousands of stationary and rotating blades, each of which had to harmonize with all the others.
- Compressor air bleeds to prevent stall.
- Variable stator blades on compressors for the same purpose.
- Fuel systems which compensate for and automatically adjust to all requirements of flight including starting, take-off, climb, altitude operation, acceleration, and shutoff.
- Aircooled nozzle guide vanes.
- Aircooled turbine blades.
- Variable exit nozzles.
- Oil cooler and anti-oilfoaming features.

Engines designed for maximum economy tended toward higher compression ratio, which led to splitting the compressor and turbine into two groups: (1) a low pressure compressor driven by a low pressure turbine, and (2) a completely independent high pressure compressor driven by a high pressure turbine. This arrangement, called two-spool, has some advantages in operational flexibility, but adds greatly to the complication.

The Bypass Jet Engine

For the same degree of complication, a good case can be made for a bypass jet engine. This powerplant taps a large proportion of air from the low pressure compressor and discharges it to the rear through an annular opening around the exhaust nozzle, without passing through the high pressure compressor, combustion chamber, and turbines. In this arrangement the air flow is increased and the average velocity of the jet stream is reduced, thereby increasing the propulsive efficiency when powering aircraft operating at velocities of less than Mach 1.

In this engine, the fuel consumption is lower than in competing types and the noise of the exhaust is much lower. The hot part of the engine is shrouded in an air jacket and therefore needs no additional shroud in its airplane installation, thus saving considerable installation weight. And the engine is as flexible in operation as the two-spool jet engine. The proportion of bypass air can be varied by design to fit a variety of airplane requirements.

Military requirements for all-out performance in combat led to the afterburner, or reheat as the British prefer to call it. This is in reality a ramjet fitted to the rear of the turbojet and rammed by the turbojet. It requires its own fuel system and an automatically adjustable exhaust nozzle, which must span the range of performance between normal operation of the basic engine and operation of engine and afterburner together.

In spite of all this complication, the turbojet has maintained and improved its essential characteristics of low frontal area, low specific weight, smooth internal airflow, absence of a requirement for heat exchange to the atmosphere, and tremendous energy release for propulsion which improves in efficiency as airplane speed is increased. The development of powerplants of this type has been so rapid that the industry is just now emerging from a state of confusion and still needs time to develop present types to a higher degree of reliability. **However, the fundamental has been established that the gas turbine, being an engine of much more rational design than the piston engine, will eventually be more reliable.**

As to performance, the enormous new possibilities of turbojets bring new operating restrictions. At or near sea level, the overall fuel consumption, which is always high, is approximately double what it would be at altitude on a per mile or per hour basis. Also, even under very low throttle conditions, the engine is a tremendous gas eater. The result of this is that once committed to the air, the plane must immediately climb to high altitude, proceed at high speed to its destination, and descend and land immediately. Should something force the plane to descend to lower altitude en route, its range would be greatly reduced, which could easily force a change in destination. Thus other items, such as the pressurization of the cabin, become an intimate part of the integrated airplane and powerplant, all of which must function properly to make possible the completion of the mission.

Because of its restrictive characteristics, it becomes evident that the jet-propelled airplane will not supersede all those with other powerplants.

Short haul jet transports are difficult to justify, since the plane cannot get to the altitude for high speed and efficient cruising between stations. Also the gain from high speed between closely spaced airports can be nullified quickly by delays en route to the airport, baggage, or other delays at the destination. It would seem far more economical to first improve the service at the terminals rather than to re-equip for extreme high speed.

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TURBOPROP:
Can Top Turbojet Power Ceiling

The limitations in usefulness of the turbojet-powered aircraft lead directly to the propeller gas turbine, or turboprop type of powerplant, which has a usefulness in extending the power, reducing the weight and frontal area, and eliminating the problem of heat transfer to the atmosphere of the reciprocating engine. **While the turbojet is being limited as previously stated to around 4500 hp, the turboprop has no such limit. It is limited only by the power-absorbing ability of a practical propeller.** The turboprop can thus put new life into present day propeller-driven airplanes and continue the advance in speed, range, load-carrying capacity, and economy of operation, carried forward so vigorously in the past by the piston engine.

The turboprop as a powerplant retains nearly all the problems of the turbojet and adds a few of its own which are of interest. For example, it is tempting in the design to favor high temperature and to operate at the highest temperature which the design will permit, since an increase in turbine temperature greatly improves both power output and economy. This is usually accomplished by blade material developments and some form of turbine blade cooling, which at once becomes a special problem for this engine type.

The reduction gear is also special to the turboprop type. And since it transmits large horsepower through a wide speed change, it has been and still is a troublesome item.

The propeller itself is sensitive because of the high tip speed and high power it is converting into thrust. It also becomes in effect an integral part of the engine, since control of propeller and engine must be worked out as a single problem. This is not easy because the characteristics of the two are so similar that the changes which the control must sense and work from, with great accuracy, are extremely delicate.

In addition to normal control, a system of safety features must be developed to keep the propeller from flattening its pitch and driving the compressor in case of power interruption. If this should happen for any reason, including momentary interruption of fuel supply, the asymmetric drag on a multi-engine plane would be so great that the airplane would surely be forced into a spin and might even lose its tail through excessive aerodynamic loads.

Because of these extra complications, the application of the turboprop to production aircraft has been long delayed but is now at hand and will have a long life ahead of it in airplanes of speed up to about 500 mph maximum. It is undoubtedly possible to build a turboprop airplane for much higher speed, but the sensitivity of the propeller to damage or erosion from stones, hail, and rain will make it unsatisfactory for faster aircraft.

TURBINE DEVELOPMENT:
$25 Million and Five Years per Engine

The development of a new gas turbine engine is a highly involved and expensive procedure which can be accomplished only by a team of competent and experienced engineers, backed by a well equipped development and production organization and supplied with what seems like unlimited funds. It has been the experience of most firms in the business that a maximum effort from the beginning is the most economical procedure. To develop a turbojet, it is necessary to design and construct all the components which must then be subjected to individual performance check and alteration to reach acceptability.

One example of such a problem might be a check of the compressor surge margin of safety under the varying conditions of altitude and acceleration—a very sticky problem indeed. In addition to performance checks, each component should if possible be given many hundreds of hours of durability testing on a rig to eliminate weaknesses which would cause delays if discovered on the full scale engine. While these endurance tests are in progress, the full scale engine would ordinarily be put together for a performance check. It will usually be necessary to make alterations to the compressor or turbine to obtain a matching of performance, since they are driven at the same speed through a common shaft and must handle an identical air mass flow.

This process is far more complicated in a two-spool powerplant, in which the matching between turbine and compressor must be done with two sets of compressors and turbines which must be mutually compatible with each other in a series relationship.

The control must also be adapted to the needs of

the powerplant under all conditions of load at all altitudes; and acceleration under all conditions of altitude and flight speed must be satisfactory.

The new powerplant, having been checked for performance at sea level and hopefully in an altitude tunnel, must have its endurance established. This is a long and tedious process at best since each deficiency must be eliminated and the correction rechecked for endurance. Many defects require fundamental analysis starting with material, carrying through the process of manufacture, as well as the design, the assembly, and the related conditions such as air flow pattern, heat distribution, vibration conditions, and a host of other considerations. The early part of a development is always most critical because the defects may be so overlapping that the engine will not run consistently, in which case little or no progress is possible.

Tested In Flight

In addition to the above, the new powerplant must be flown as soon as possible to check out actual performance and running characteristics at altitude. This is usually done in a specially equipped plane with other engines of known durability to insure safe return to base. This type of flight testing is seldom able to check out flight characteristics at the velocity of flight for which the engine was designed. So the tests must be repeated in a high speed airplane when the new powerplant has reached the point of reliability to make this a safe procedure.

The completion of a satisfactory 50-hr endurance test is considered sufficient proof for this phase of flight testing. This latter flight test should be done in the new airplane for which the engine is intended to check out the inlet duct and other airplane parts which affect the powerplant performance drastically and frequently detrimentally.

It has been found from the experience of most engine companies that 12 prototype engines are about the right number for a full scale development. Eight of these will be put on stand and tunnel testing, and three on flight testing. Each engine should be able to accumulate about 30 hr per month for a total of 240 hr per month—or 3000 hr per year. More prototypes will not usually produce more hours of testing, but fewer prototypes will produce fewer hours of testing. The test stand running prior to type test will be at least 3000 hr and might be much more.

This is only a start since twice this amount of test running will be required before the engine goes into full production. While the engine is in production, experimental test running will continue at about 3000 hr per year, required largely to check production materials and processes and design changes required to correct defects discovered in flight and at overhaul.

It can be seen from the very sketchy outline above that a modern aircraft powerplant requires a staggering development effort, the cost of which can be approximated at $25,000,000 minimum, exclusive of production tooling cost. The time required is at best five years and may be considerably longer.

The initial configuration of a powerplant will never achieve its ultimate capacity, since each component can not reach its optimum point on the first try and the combination can not be in perfect harmony. This leaves room for future growth; and once a powerplant has been through its initial development, it becomes economical of time and money to carry it to the maximum performance for which it is capable. This is usually done by increasing the air flow through improvements to inlet ducting, adding additional stages to the compressor, increasing the compressor efficiency and possibly compression ratio, decreasing the pressure drop through the combustion chamber or chambers, increasing the capacity and efficiency of the turbine, improving air and fuel distribution in combustion chamber and turbine, and the like. Also, increasing turbine temperature is quite effective in reducing fuel consumption and increasing power on a propeller turbine; but on a turbojet the maximum power alone is improved at the expense of fuel consumption unless the compression ratio is increased to correspond with the new temperature.

It is possible to make a scale model of a successful engine in a different size. But the scaled engine, to be competitive, must anticipate in its design the new features which will be present in the mother engine when the scaled engine is ready for production. Beyond this handicap there are the laws of physics and mechanics which give to the scaled model completely different vibration and Reynolds number characteristics and which change the ratio of clearance to blade height. All these factors dictate that an engine scaled to a materially different size is practically a new project and requires a full course of development.

The tremendous increases in flight velocity demanded by the military for all tactical aircraft, except patrol, require larger and larger jet engines. This leads to a very difficult situation because the cost of development and the elapsed time it consumes seem to vary as the square or cube of the engine size. Also the cost of tooling the engine and the cost of the final engine fall into this same relationship with size, which could even strain the national resources if a full-scale war activity were built around a variety of large jet engines.

For cost and other reasons related to the rapid rate of obsolescence of a waiting engine, the proposal to develop a series of engines to cover the spectrum of required sizes seems to be a wasteful and ineffective procedure. It would appear that some new thinking is required to solve the very difficult problem of making available jet engines to power a wide variety of aircraft, most of which require very large thrust ratings.

Jet Engine Size

Let us now look at the characteristics of the turbojet engine in terms of size. It is well known that the air swallowing capacity of this type of engine is proportional to the square of the lineal dimension, while the weight is proportional to the cube of the lineal dimension. Of course, this relationship is modified by other factors, but let us examine these.

- First, the Reynolds number effect does not vary much within limits of existing sizes but is favorable to the larger engine.

- Second, the ratio of practical running clearance space to blade height is favorable to the large engine,

but the effect is not large except on very small engines.

● Third, the weight of the accessories, accessory drives, fuel system control, and similar parts is relatively constant and becomes a large proportion of the total engine weight in the small version.

Neglecting the accessories and drives for the moment, if an engine is designed for minimum specific weight in terms of thrust, it will be a small unit of say 20-in. diameter which might be capable of 4000 to 5000 lb of static sea level thrust. But the requirement is for four or five times this much thrust, and we have not yet added the accessories.

Let us now consider that the 20-in. engine is one cylinder of a multicylinder unit. No basic reasons appear which would prevent grouping two, three, four or more such engines in a line or in a cluster and fitting them with one common group of accessories. Thus with one comparatively easy development one moderate development cost, one time schedule, one production tooling cost for really high production quantities, a series of jet powerplants can be obtained of say 4000, 8000, 12,000, 16,000 and 20,000 lb thrust, the weight of which would be roughly one-half the weight of a single unit engine of 12,000 lb thrust and still less than that in the larger sizes.

Now what will the aircraft manufacturer say? First, that he cannot use the powerplant because it does not fit into his present airplanes or the one he has planned for three to five years hence. However, when he realizes that such an engine will have a weight of 0.18 lb per lb of thrust or less against current large engines of twice that amount and when he realizes that the *multiunit engine* can and must be pod mounted to preserve its optimum configuration, he will put his ingenuity to work and come up with a long step forward in airplane performance.

Let us review what this proposal accomplishes in the 12,000-lb thrust size:

1. Reduces weight from 0.3 to 0.18 lb weight per lb thrust.

2. Reduces cost of development from $100,000,000 to $25,000,000.

3. Reduces tooling cost from $40,000,000 to $15,000,000.

4. Reduces time when engine series will be available from 1965 to 1960.

5. Makes possible the production of the complete series of engines to meet any foreseeable requirement.

Have I exaggerated? Engine builders and airplane designers, set your own analyzers to work and determine the answer for yourself.

OTHER ENGINES:

Translating Dreams into Reality

Other applications and other types of powerplants might be briefly mentioned.

The helicopter has to date successfully used the reciprocating engine largely because it was the only powerplant available. Since this type of engine is not particularly well adapted to this service, it is probable that a form of gas turbine will supersede present engines which may take the form of a gas generator, the output from which is burned at the rotor tips. In this application, the reduction gear and drive shafts are eliminated and an air jet is the only connection between the powerplant and the rotor.

Pulsejet powerplants, in a much more developed form than the German V-1 or its derivitives, could have good application on helicopter rotor tips where the direct application of power would solve many present problems by returning to that most desirable but easily lost condition—simplicity.

Atomic energy in an aircraft powerplant would seem to be competitive with a chemical fuel powerplant where extreme range at high speed is the major criterion. In such a case, a reactor can be substituted for the combustion chambers of jet engines through the use of one or more heat transfer devices. Since the fuel for a single flight has practically infinite energy and no weight, this would be a most favorable arrangement were it not for the heavy shielding required to protect the personnel aboard from radiation. The weight of the shielding required dictates a large airplane to carry this heavy load.

Advances have already been made in reducing shielding weight and **much more can be expected which may improve drastically the position of atomic energy as a source of power for aircraft.**

Extension of all the developments suggested herein to the ultimate possibility of each, and harmonizing each to all the others, will require a great quantity of money, effort, and time and should keep the industry busy to the close of the century. By that time other startling discoveries may appear, such as the transmission of energy over long distances by means of a beamed electrical field which would result in replacement of powerplants in aircraft by energy converters.

● I will predict, therefore, the elimination of aircraft powerplants as we now envision them by the year 2005, the 100th Anniversary of the Society of Automotive Engineers.

From Gold to Diamond in Air Transport Engineering

by William Littlewood

SAE is currently 50 years old—powered flight is about the same—but air transport is little more than half that age. Therefore, air transport forecasts for the next half century based on nostalgic contemplation and future projection would inevitably be a little uncertain.

A few years ago we did base a number of air transport forecasts for a limited period of some 5 to 10 years on such indicated technical trends. The short history since has confirmed the reasonableness of that method at that time even with its limitations. However, within the longer future time period we will obviously be faced with already indicated growth problems and changes in performances and types so radical as to alter basic parameters and leave serious doubt as to the smooth extensions of such trend curves. We must, therefore, resort to other methods of forecast.

We are faced with almost assured continuous and substantial growth in the size and complexity of our business, both in the operation of aircraft equipment and in the handling of people and goods. We are already witnessing an accelerated change to the use of turbine type powerplants of one form or another, with accompanying alterations and permissable extensions of altitudes, speeds, and ranges of operation.

We can easily envision, within our time period, the application in our operating aircraft of greatly improved materials, structural methods and novel aerodynamic principles and techniques, as well as the use of radically altered propulsion devices, possibly employing higher energy fuels and even remotely incorporating some aspects of atomic energy.

It is most fortunate for the author that others, more competent than he, are elsewhere in this issue dealing with the future developments in flying machines and associated equipment, and of propulsion devices and related accessories. He accepts, without debate, their statements and conclusions with respect to the types of flying machines and powerplants and equipment to be used during the next 50 years, and will devote his comments largely to problems incident to the application and use of such devices in air transportation.

There are, I believe, two things that we can accept as fundamental in our consideration: (1) that our basic attack on the problem must not be a "Jules Verne" approach to the detailed examination of methods of accomplishing specific future technical objectives, but rather an inquiry into what areas and broad questions of technical and engineering development will be needed to solve these technological problems; and (2) an optimistic

SAE Golden Anniversary Author

William Littlewood, 1954 SAE President, is vice-president of American Airlines, Inc., with headquarters in Washington, D. C. His activity in the aviation field dates back to 1927 when he joined Fairchild Engine and Airplane Co. as production manager. In 1930 he moved to American Airways, Inc., which became American Airlines, Inc. in 1934.

He was born in New York City in 1898 and attended Long Island public schools. He went to Cornell University, graduating in 1920 with a degree in mechanical engineering. While a student at Cornell, he received the Sibley prize, a symbol of the highest rating in engineering studies for two consecutive years.

Littlewood has long been a member of the National Advisory Committee for Aeronautics, having served as chairman of that group's important Committee on Operating Problems. He has also been a member of the Aeronautics Committee of the Research and Development Board, and a consultant to the Air Research and Development Command.

Littlewood is a fellow and past vice-president of the Institute of the Aeronautical Sciences.

His contributions to SAE are well known. He was vice-president representing the Air Transport Activity in 1945, has been an SAE-designated director of the Coordinating Research Council, served as a member of the Aeronautics Division of the General Standards Committee from 1940–1944 and was chairman of the Aircraft Accessories & Equipment Subdivision during that period, and has held many other important posts.

William Littlewood

As a Cornell alumnus, Littlewood is a director of the Cornell Aeronautical Laboratories, has served several terms as a director of the Cornell Alumni Association, and is a past-president of the Cornell Society of Engineers.

agreement that within 50 years almost anything material that we can clearly discern today as needing to be done, can and will be accomplished.

In seeking answers to our first premise we, perhaps, should start by examining the second. And lest our second statement be classed as undue optimism, I invite your contemplation of the state of our art and hopes 50 years ago. More than reasonable men could conceive at that time has been accomplished and exceeded. What do we see today as areas of greatly needed improvement or desired technical advance in air transport equipment performance, operations, and service to our customers?

1. OPERATIONAL RANGE:

The World Will Keep Shrinking

Let us first look at what we may need and propose to accomplish in the carriage by air of people and goods. It is already evident that the inherent ability of airplanes to cross mountains, rivers, and seas will ultimately achieve the elimination of boundaries and coastlines as significant points of arrival or departure. We will go from where in the world we are to where in the world we wish to be—from any city to any other, if that be our common objective in adequate numbers. And, as transportation history has shown, the initial accomplishment of such an objective generates the need for additional service. In other words, it establishes a community of interest where none was apparent before.

With such a concept goes, of course, essential requirements in ultimate range for aircraft intended

for services between remote points of the earth, which will throughout our time period be establishing ever increasing travel and commerce at ever increasing distances. We might conceive that the ultimate desired range of aircraft would be in the neighborhood of 12,500 miles. Any additional distance, barring wind effects, could be achieved by reversing direction around the world! And to almost that ultimate range, there will, I believe, ultimately be commercial aircraft capable of nonstop flight.

In this connection it is interesting to note that every increase in potential aircraft range has been enthusiastically received by the traveling and shipping public, and has quickly established a travel pattern involving increasing resentment toward intermediate stops. This world shrinking characteristic of aviation has often been noted, but it has never been so apparent as it is today and will be in the future.

In examining the range requirement picture for the future, we must not forget that our present cities will remain established in fixed locations at fixed distances. They will undoubtedly grow and there may be more of them, and travel requirements between them may change; but the composite range requirements for air transport will include all ranges from the shortest feasible to accomplish a desired service with reasonable economy to the expanded maximum ranges previously discussed.

2. *SPEEDS:*

Mach 1+ Still a Long Way Off

Essential accompaniments of the increased ranges of operation (at least as we know powerplant characteristics today and suspect their probable development trend) indicate that in such services we will fly higher and consequently faster, and that our fundamental aircraft sizes will increase, all as related functions of operating ranges. There are practical limitations on all of these characteristics, and we might spend a moment looking into the crystal ball with respect to each.

Speed meets an economic brake at Mach 1. To that point, the laws of lift and drag and resultant

Soothsaying — Not Salaries

THIS discussion does not deal with the financial rewards of air transport engineers as the title might mislead you to believe. It merely expresses some thoughts on what may happen in air transport technical development during the next 50 years —from SAE's Golden Jubilee to its Diamond Anniversary.

Before we pick up the crystal ball and undertake the grave risk of losing any reputation we may have acquired for sound and conservative judgment, we should perhaps take a brief look at some aspects of the philosophy of prophecy. A sound engineering basis for this discussion might be established by proposing a formula—

$$A = \frac{1}{T^n}$$

in which "A" is the nondimensional accuracy of forecast, "T" is a number representing years in the future, and "n" is an exponential factor in all cases greater than 2.

Yet prophecy is a rather safe business. If by some chance one be reasonably right, he immediately acquires the reputation and honor of a Nostradamus. If he be wrong, his "guesstimates" and the soothsayer pass quickly into the limbo of forgotten things.

economics are known and acceptable, and control and flutter problems are relatively simple. But, there the increment of drag and cost with speed abruptly rises and thereafter continues higher than it had been before. However, it seems completely reasonable that within our time period principles of dealing simply with control and flutter problems, and of drag reduction will be developed, and even reasonable solutions in common use, to the problems of approaching the thermal barrier will be achieved. These will permit us to use efficiently with adequate economy and improved service for long range operations the advantages of speeds far beyond Mach 1.

While speed of overall accomplishment is a basic objective of all air travel, and speed of flight is an essential ingredient of long range transport, it is much less important in medium and particularly short range operations, as flight time becomes a smaller percentage of total travel time. The flight speed advantage of air travel will show an ever increasing margin over any other form of transportation—a modest increase in short range operation and a great increase in long range performance. But, in short and medium ranges of operation, the emphasis must be heavily on the reduction of incidental time losses on the ground which defeat the flight speed advantages of air travel in such uses. This subject will be discussed in more detail later.

3. ALTITUDE:

50,000-ft Ceilings Will Be Common

As to altitudes, we can, and will, use any altitudes necessary to achieve the desired speed to accomplish our range objectives and consistent with meteorological aids and hindrances. As our long range altitudes increase to values above 50,000 ft, we must give increasing attention to the physiological problems of passengers and crew—to possible cosmic ray effects, to ozone and ultra violet concentrations, and to the ever increasing challenges of cabin air conditioning and pressurization, recognizing the disastrous results of explosive decompression, and even giving some thought to meteorite collision possibilities!

As with speed, we will remain conservative for pure economic and performance reasons, in our altitudes for shorter range operations. Our powerplants will probably continue to be of types considerably benefitted in efficiency of fuel consumption by appropriate altitude increases—but short-range flight does not lend itself to high altitude performance. You have to start down before you get up!

4. SIZE:

All Plane Types Will Grow

Size, in the largest and longest range types of our conceived developments, is still susceptible to the square-cube law of diminishing returns, although developments in materials and structural design and fabrication methods will be greatly compensating. Sizes must continue to be geared to economic needs to achieve consistent, satisfactory load factors. I think the principle will still apply that the smallest airplane which will in all respects best perform the required service will be the size most desirable.

Smallest Will Grow Least

How large the maximum sizes will be, I will not attempt to guess. There will be size increases in all categories consistent with the increased unit needs and loads in a continuously growing air transport picture. The smallest sizes of airplanes in purely local services, always on the fringe of economic suitability and appropriateness of air travel, will undoubtedly grow the least. A strong influence tending to encourage larger unit sizes in all uses will be the ever increasing air traffic problems at and near terminals.

Personalized Service

The character of air transportation is significantly expressed by the unique personal relationship which exists between the airline and the passenger or shipper. This is evident in no other form of transportation, and has, as much as anything else, I believe, accounted for the phenomenal growth of air transportation during its first 25 years while it has been overcoming critical technical and economic problems.

A symbol of that personal relationship and service is expressed by the customary lack of any physi-

cal barrier between the airline passenger and ticket agent and by the basic treatment of airline passengers as individuals. The airlines started out and grew with this concept of personal service and must never lose appreciation of its importance. This is not exactly an engineering problem except perhaps, as it relates to terminal layout and ticket counter design, and to service methods and items of all kinds; but it is an inherent characteristic of airline thinking and a major element in continuing success.

The public loves to "see the wheels go round" and feel a part of the travel adventure. There is no better way to achieve this rapport than by keeping the wheels bright and shiny and out in the public view. As the business and personal contacts inevitably grow in number and we are forced for capacity and efficiency to adopt machine methods for many elements of customer contacts, we must strive not to lose that personalized character which is so unique and worthwhile in airline service. Here is a problem in "human" engineering.

Costs Will Rise

As to economy of future operations, we must disregard the present inflationary cost trends. Who could outguess such complex economic factors? But, we can recognize certain significant cost elements in aviation and the air transport future. We are continually demanding that more and more things be done in a more complete or more precise way. Air transport, in all aspects of equipment and methods, is being refined!

The new ideas are intended to improve the safety, dependability, and comfort of air travel. And, to the extent that they do they are desirable and not to be denied. Some are devoted to improved economy. But, they usually result in complexity (a doubtful element of improved safety or economy) and always tend to increase procurement and maintenance costs. So size, quantity, quality, and performance will probably all increase, with accompanying complexity—and costs will rise.

More Service per Dollar

Compensating factors will be increased production quantities, improved manufacturing methods, more federal and industry supported research and development, hoped-for economies in materials and fabrication techniques, more standardization or uniformity in product details (especially those affecting safety or public convenience and comfort), lower relative costs of fuels and operating materials, decreased specific fuel consumptions and improved thrust and aerodynamic efficiencies. And, above all will be the basic continuing increases in size, performances, and efficiencies to help give reduced unit operating costs. We may well continue to hope and expect to operate air transport services that are better in all respects for very small increases in price considering the ever increasing value of the services to be rendered.

5. PASSENGER SERVICE:

Faster, More Comfortable Ground Handling Due

And, now we come to an area of future air transport where we can speak with some assurance. The needs are so acute, and will rapidly become more so, and some of the causes are so evident, that in the fields of comfort and convenience the developments await only economic justification—which is already at hand in many instances—and imaginative perception to visualize and implement the corrective developments.

It's Overall Speed That Counts

We have mentioned the importance of ground time losses as affecting even the justification for short-range air transport. What the traveller or shipper is really interested in is the overall time required from origin to destination. Realization of this places full emphasis on the passenger or cargo collecting problem at origin, the transportation problem from collecting point to airport (be it heliport or airplane field), the interconnection problem, the incidental time losses of ticketing, baggage handling, transport to and into the plane, delayed departures, plane taxiing time losses, plane traffic delays at departure; and similar problems in reverse order on arrival at an airport and before reaching the desired destination.

What can and must be accomplished in these respects during the coming years? We will have multiple collecting points in the larger metropolitan areas covering suburban residential communities, hotel and business concentrations. We will have express highways interconnecting these collecting points, and joining these with the interconnected multiple airports. All this on the ground when geographical conditions permit and traffic justifies.

Connecting geographically separated elements of such an expanded metropolitan area and reaching out increasing distances to other communities will be vertical riser aircraft—employing some reas-

onably efficient developed types of such aircraft—possibly resembling the present helicopter in general performance characteristics and having a remote resemblance to some of its aerodynamic principles.

Vertical risers present a rapidly changing and developing field of engineering, all too much of which is now in the field of empirical design. Such devices have potential attributes and performance characteristics which are so essential to an integrated transportation picture that they must be realized. My crystal ball does not show the exact solution or combination of solutions.

Bus To Plane Easily

And now at one of the multiple airports we must get our traveller aboard the airplane—comfortably and quickly. If he is to go a short distance in a relatively small airplane, we may well relieve him of his baggage, or leave it with him, as he desires, and board him directly onto the close-in parked plane under a weather protecting canopy—using escalators, of course, if any changes of level are involved.

He will probably have been ticketed, without reservation, in a simplified manner enroute to the airport, or by a machine punch and automatic change maker before or after his trip to the field. Or he may use a keyed scrip card which will machine deliver to him the desired ticket and charge his account! And, if he is to travel a longer distance, he will be ticketed (again by simplified processes), relieved of his checked baggage, and, when ready, transported by a suitably designed conveyance, all weather protected, from the convenient accommodations of the terminal building to the efficient location of the long range airplanes near the operating runways.

Current Practice Projected

This is not a new idea. It is being done today in a limited sense with equipment not ideally suited to the purpose and without the traffic controls which would be necessary for a high density operation. But, it works and offers the most practical and expandable solution suggested to date for a future problem which is already on us.

Better Traffic Control

The airplane is loaded and hopefully on its way. Its departure must not be held awaiting slow instrument landings on the same runways. So multiple runways—simultaneously useable—must be available. And, the incoming airplanes must not be held before landing an hour or more in a stack or stacks. Therefore, our traffic control equipment and procedures must function to control incoming planes from far out. The airplane, on arrival, must be guaranteed an almost straight-in landing without delay. And this is almost possible today by agreement and cooperative control! It must be a basic feature of the future if we are to realize the potential values and economies of the increased traffic and airplane characteristics of the coming years.

All-Weather Dependability

Added comfort and convenience will also characterize our transport airplanes and their operation for the future. We have every reason to confidently expect smoother, quieter flight at lower equivalent altitude cabin pressure levels, despite the greatly increased flight speeds and altitudes. We will have adequate and dependable radar, and perhaps other devices, to avoid undue turbulence or hail. We will be able with assurance to count on and to use jet streams when they help, and avoid them when they would hinder. Automatic landings and fully adequate ice protection will insure 99.44% operating factor. Future traffic on the airlanes, as well as in the vicinity of terminals, will be precisely controlled so as to insure safety against collision. Such traffic controls must ultimately apply to all operating aircraft, and will be continuously monitored from the ground.

6. SAFETY:

Keyed to Proper Passenger Packaging

And, now a few references to safety in air transport. We are quite familar with the amazing ability of the human body, properly supported and protected, to withstand violent deceleration, as in a crash. Our present vehicles fall far short of the human capacity to endure such shocks. So, one basic objective of our future designs must be to approach closer to balance in these respective capacities and abilities for the good of all.

Almost unbelievable crashes—involving 50 or more g—can be successfully withstood—providing the human body is adequately restrained, providing the container (or fuselage) does not open up and spill out its contents, providing it does not collapse and crush its delicate cargo, providing the human body does not hit hard against the container or

some hard object within it, nor is hit by some object acting as a missile. Barring these eventualities, we could make our container take as much as nature has given our bodies the ability to withstand, and we will, in coming years, accomplish a good part of that.

Of course, we hope and count on the coming years further decreasing the number of occasions on which crash safety is an important consideration. But we will probably always have some accidents—and we can be much better prepared for them.

The problems of aircraft structural fatigue life and failure are of grave concern to us all at the present time. This is largely due to the fact that we have given the existence of these problems "lip service," but are just beginning to face up to them and institute preventive and corrective measures in the laboratory and on the drawing board. Easily overriding the costly and illogical assumption that a "fatigue life" must be pre-established as a compulsory retirement program for an aircraft or major elements thereof, we can provide what is needed to control the situation with assured safety and economy.

"Fail-safe" design for multiple critical structural elements, with controlled slow onset of inspectable structural fatigue cracks, and design for ready replacement of any such incipient failures, seems to assure a satisfactory solution. We will have such provisions in future transport airplanes. And for the explosive decompression problem of high altitude fuselages, the inclusion of proven techniques of rupture-proof design for the pressure capsule will readily insure against such a hazard!

Standardize Passenger Gadgetry

And now let us enter a plea for "uniformity" in air transport in all those details with which the public comes in contact and which directly influence emergency safety—such things as emergency exit and door operation and functioning, and their location and use of emergency equipment of all kinds. Of course, we expect to see such obvious non-competitive benefits achieved in our future picture, and we may even hope that the same uniformity will be helpfully extended to cover all details of the traveller's comfort and convenience, such as seat adjustments, light switches, ash trays, call buttons, and even "urp" cups!

7. NOISE:

No Easy Answers in Sight

A matter of grave concern even today, and of increasing moment in the future, is the problem of noise, primarily as affecting community relations in the vicinity of airports, but also as affecting workers and travellers at the airports, and influencing the comfort and efficiency of transport airplanes.

Getting Along With The Neighbors

The current problem is a compound of noise and vibration as affecting the airplane and its efficiency. It is a compound of noise, annoyance, and fear as affecting community relations. The hoped-for ultimate answers will be an adequate control or suppression of noise at its source—which will directly benefit all aspects of the problem. Answers are now being sought in that area without much immediate success. Various panaceas such as reduced tip speeds for propellers and reduced jet stream velocities, are only partially applicable and frequently defeat the desirable developments of good efficiencies or high speed performances. Operational controls and good public relations are currently effective in the community problem, but leave the future uncertain as higher unit powers and thrusts from larger noise producing sources, and more frequent operations, are forecast.

Here is a problem in which the future is clouded—but the urgency is so great that we must assume satisfactory answers will be forthcoming, short of moving all airports out in the country! Incidentally, moving airports to the country is no answer, because the cities follow right along!

There seems no doubt but that the future holds assurance of almost limitless developments and improvements in performances and efficiencies, insuring better air transport services in all respects, and well within the limits of economic acceptability by an ever growing army of air travellers and shippers. We will have suitable machines, undoubtedly of the essentially vertical riser type, to perform the versatile services associated with relatively short ranges—nominally too short for conventional airplane services—and where flight speed is of secondary importance but where close-in operations are essential to achieving satisfactory overall time performance.

Air Transport Offers More Than Speed

Such services will be established where traffic density in short range operations does not justify the establishment of expensive express highways or high capacity ground transport services, or where geographical obstacles exaggerate the measured distance in ground or water transport time.

We will surely have good "local" operations airplanes performing the essential services by air

between small communities, and linking them with the larger urban centers. How much better than present airplanes for such relatively marginal air transport services the improved types will be, is difficult to foretell. But they will be at least as much better than the present airplanes as several new pieces of paper can make them during the next 50 years, and they will take full advantage of the inevitable advance in the "state of the art" in all areas as it is applicable to the basic economic problems of such services. They should not grow much in size nor do they need to increase much in performance. They must be simple, rugged, and economical in operation.

8. FUTURE TRANSPORTS:

Need for Four Types

The larger domestic airlines will need three or perhaps four basic type airplanes. First will be a short to medium range transport for passengers and some cargo. This will continue to have fairly modest speed, performance, and altitude characteristics, both in consideration of the average short range requirements. Its capacity will grow modestly with the basic growth of unit traffic requirements. It will start as a four-engine turboprop type, but may well shift to a unique turbojet type within our time period.

It will eventually have all the efficiencies and features that advances in the "state of the art" will provide. It will never need all the features, nor to the extent required for the ultimate longest range, highest altitude, fastest and largest transports. But it will have assured all-weather capabilities and all indicated protective devices to insure fully dependable, comfortable, and economical operations to a range sufficient to overlap the minimum efficient range of a long range domestic transport.

The second domestic passenger transport will be for long range use, and will probably be a large (200,000 lb plus), high speed (possibly above Mach 1), high altitude (50,000 ft plus) turbojet with four comparatively quiet powerplants having very flexible thrust characteristics and low specific fuel consumption! "The wish is father to the thought!" These powerplants, combined with an airplane of new, lighter weight, higher strength materials; having improved structural design and fabrication techniques, and built-in fatigue resistant and protective features, and rupture proof fuselage design; incorporating very high lift and low cruising drag characteristics; plus the thousands of improvements in performance and efficiency that will inevitably accrue to the "state of the art" development in all quarters, will give an air transport leader rendering the finest services at low cost!

There is also a growing need—probably to be acutely felt and accommodated well within our time period—for a domestic transport of modest performance and range but having very high unit passenger capacities. As long as our citizens insist—and I see no change except an area "spreading out"—or living in metropolitan communities of ever increasing size, we will need an airplane to handle large passenger loads for relatively short distances and therefore, at modest speeds and altitudes. Neither of the above airplanes meets this need.

Another already indicated need is a cargo plane, (or planes), designed expressly to satisfy the needs of such services. Modest performance and suitable capacities with needed ranges to insure low cost per ton-mile operation are the essentials. The other ingredients of the successful development of cargo services—which promise to be ultimately the giant of air commerce—are adequacy and dependability of scheduled services over appropriate cargo trade routes, combined with efficient and dependable pick up and delivery services door to door. There's a lot to that problem!

How much of our long range intercontinental services will be rendered by the long range domestic transport, only the future can tell. But if we are to realize the full possibilities of the longer ranges mentioned earlier, there will probably be a larger, and perhaps even faster and higher, airplane for such routes.

The engineer's proper concern with the future of air transport is his natural interest in what part he can play in its development. I have tried to emphasize throughout this very incomplete discussion the extreme versatility of requirements and the breadth of the problem. All kinds of engineers will work and solve all kinds of problems to accommodate the overall needs of air transport during the next 50 years—as in the past.

One forward looking request of 1953 that came to my desk was to **"State in 50 words what will develop in air transport in the next 50 years!"** This seemed like quite a formidable assignment, but I think I can answer it and at the same time give the engineer some primary guidance.

To put it concisely, I will say, **"During the next 50 years in air transport there will be much more of the same!"** I have taken much more than 50 words to say here that **"We will fly faster; we will fly higher; we will fly farther (as we wish and need to); we will carry more people and goods (and I hope a minimum of guns and ammunition)—more safely, more comfortably, more dependably, and more cheaply!"**

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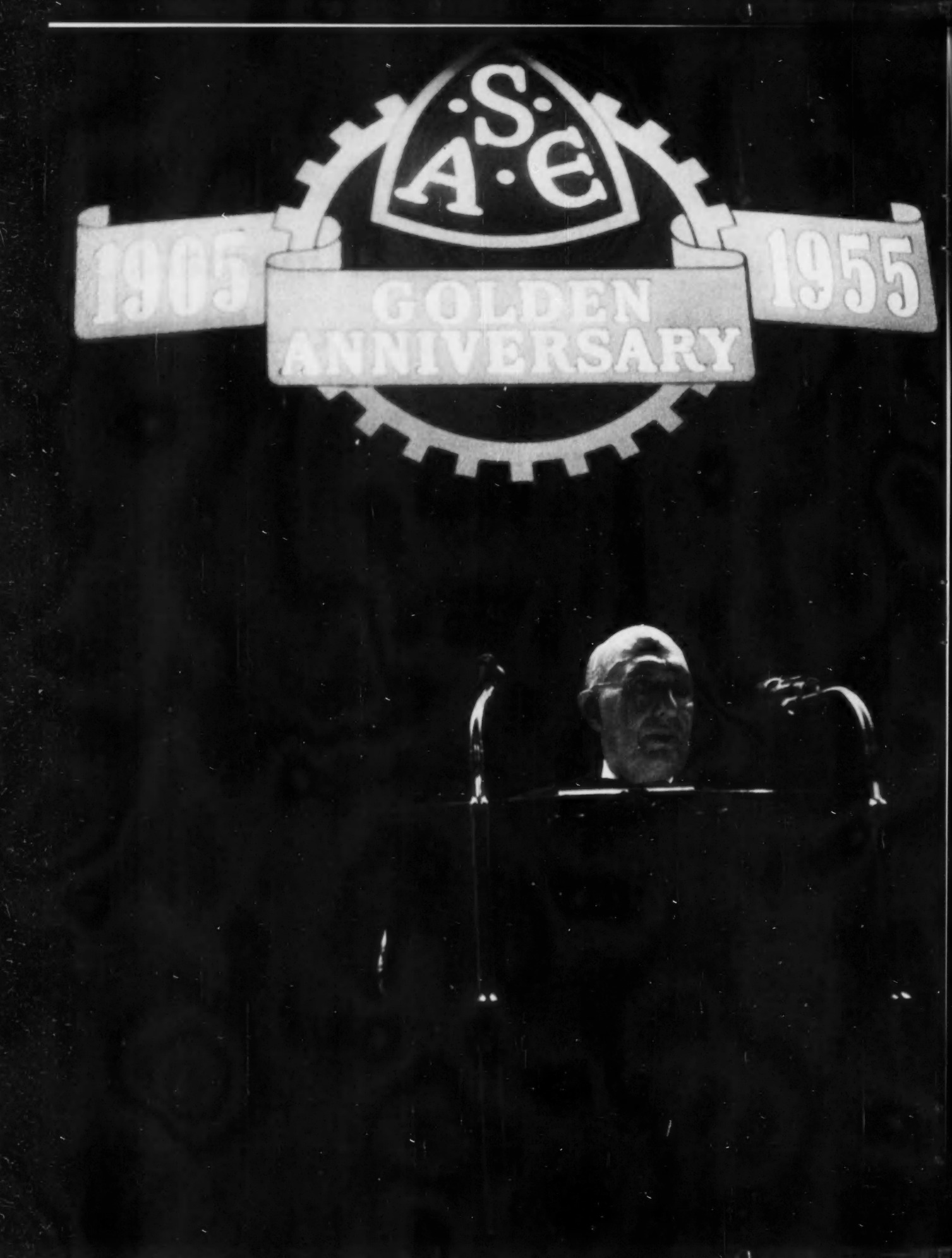
Every paper is indexed by:

1. ***Original title.***
2. ***Journal headline.***
3. ***Authors' names.***
4. ***Subject headings.***

When the **Journal** article contains discussion, the names of the discussers are also listed.

The 1954 INDEX covers all material published in the **Journal** during 1954, based on the following:

1. ***Papers presented at National Meetings.***
2. ***Papers presented at Section Meetings, received at SAE Headquarters.***
3. ***Round table and production panel reports received at SAE Headquarters.***


S·A·E
1905
1955
GOLDEN
ANNIVERSARY

THIRTY-TWO PIECE ORCHESTRA ENTERTAINS 2700 MEMBERS IN DETROIT'S HUGE MASONIC TEMPLE

1955 Annual Meeting Celebrates SAE's 50 Years

SAE celebrated the 50th anniversary of its founding by staging its biggest and most gala meeting —the SAE Golden Anniversary Annual Meeting in Detroit, Jan. 10–14, 1955.

More engineers than ever before gathered to discuss mutual engineering problems and to estimate the future on the basis of extrapolations of the past.

Old friendships were renewed and old rivalries forgotten amid reminiscences of the Society's early days. New friendships were formed and current problems solved in the easy-going atmosphere of committee rooms and session halls.

Newcomers to SAE who had had their first taste of Boss Ket's wit at the Golden Anniversary Banquet chuckled as they heard earlier Ketteringisms retold by old-timers.

And the discussions of turbine fuels . . . automation . . . smog . . . vapor lock . . . V-8 engines . . . plastic truck bodies . . . and scores of other subjects covered in the meeting's 57 papers and two round tables went on, too. Engineers debated them in the elevators and corridors of the Sheraton-Cadillac and the Statler, along the sidewalks connecting the two hotels, and in restaurants all over town.

BENEATH THE EMBLEM of SAE's Golden Anniversary "Boss" C. F. Kettering tells fellow members that the next fifty years have unlimited possibilities

Present in Detroit were scores of men who had sat across the committee table from each other for many of the Society's 50 years and thrashed out their differences so that standards could be formulated. After handling current business, they got together in the evening just to enjoy each others' company.

The executive committee of the Iron and Steel Technical Committee, for instance, was joined at dinner on Thursday by half a dozen of its "alumni." Retired members shed light from their past experiences on today's issues and assured younger colleagues that retirement isn't bad at all. L. A. Danse showed colored movies of his post-retirement trips on the Coast Guard ice-breaker "Mackinac." Others described the gardens, grandchildren, and globe trotting that they now have the leisure to enjoy. Harry Knowlton, on the basis of two-and-a-half weeks of retirement, reported only that he felt like the fellow who, falling off the Empire State building, said as he passed the fifth floor: "Well, I'm all right so far."

Old-time SAE members mingled with members of the future who are now SAE Enrolled Students in schools of the Detroit-Windsor area. From the SAE

HARRY E. CHESEBROUGH opened the Golden Anniversary Dinner by extending to the 2700 dinner guests a welcome from the Detroit Section, of which he is chairman. As chairman of the Meetings Committee, under whose direction the meeting was run, and a speaker at one of its 26 technical sessions, Chesebrough had a busy week

Student Branch at Detroit Institute of Technology came 30 students to act as ushers and preprint salesmen . . . and to absorb, as well, much practical engineering lore. An SAE Student Branch group from Ohio State University put in an appearance, too.

Conspicuous among SAE's distinguished senior members present at the meeting was P. M. Heldt (M '06) who received the first of a series of plaques to be awarded this year to pioneer members. The presentation was made at the Golden Anniversary Banquet by T. D. Kosier, who at the 1954 banquet received Detroit Section's Henry Ford Memorial Award for the best paper submitted by a junior member.

Representing the younger members, Kosier recalled how Heldt recommended in an editorial in the magazine "Horseless Age" in 1902 that a society of automobile engineers be formed. It was this suggestion that led directly to the founding of the Society of Automobile Engineers, as SAE was first named.

Kosier paid tribute to the service that Heldt rendered his fellow members and the industry as an editor of automotive trade journals and a writer of textbooks. In accepting the plaque, Heldt spoke of

SHAPING UP THE AGENDA for SAE Council meetings are SAE Secretary and General Manager John A. C. Warner (right) and the two SAE Presidents who were in action at the Golden Anniversary Meeting. William Littlewood presided at the last meeting of his 1954 Council; C. G. A. Rosen at the first gathering of the 1955 Council—both of which met on Friday morning

79-YEAR-OLD P. M. HELDT (left) was honored as the representative of SAE's pioneer members at a brief ceremony during the Golden Anniversary Banquet. Author of a 1902 editorial in "Horseless Age" which first suggested a society of automobile engineers, Heldt received a plaque from 33-year-old Thomas Kosier, representing the young engineers in whose hands lies tomorrow's SAE. Kosier, a Ford engineer, was host to Heldt before the banquet in a visit to the Ford Museum, where these pictures were taken. "Mr. Heldt can tell you an interesting story or an experience recalled by almost every car in the museum," Kosier said after the visit

the satisfactions he has found in participating in the Society. "May SAE continue to flourish for many years to come for the benefit of its members and for the benefit of the industry it serves," he said.

The Golden Anniversary banquet had the flavor of a big family birthday party. Song leader Dick Grant walked out on the vast stage of the Masonic Temple while the banquet guests were assembling in the auditorium after the dinner. Then, he rallied them into a great chorus harmonizing on familiar old songs. Never was there a heartier sound under that huge roof than when 2700 SAE'ers sang "What's the use of worrying? It never was worth while—*SOoooooooo*, pack up your troubles . . ."

1954 SAE President William Littlewood presided, calling himself the "pater familias" of the Society. He introduced SAE Past-President Delmar G. Roos, who in turn introduced the Society's thirteenth president and undisputed favorite "Boss," Charles F. Kettering.

In a thumbnail sketch for the SAE members who have not had the good fortune to know Ket first-hand, Roos reviewed Ket's part in the development of the electric starter, tetraethyl lead, diesel engine improvements, and many other advances. Beyond all these, Kettering will probably be remembered longest for his humanitarianism in inspiring and financially supporting cancer research, Roos said as he introduced Ket as speaker on "The Next Fifty Years." (See excerpts on pages 112-113.)

HAIL TO

BIRTHDAY Banquet Premieres SAE March

Composed by Macy O. Teetor

"Hail to the SAE," a march composed by Macy O. Teetor (M '24), had its premiere at the Wednesday evening banquet. Teetor himself played the march on the organ to the accompaniment of Del Delbridge's Orchestra at the start of the Golden Anniversary celebration in the auditorium of the Masonic Temple.

President Littlewood introduced Teetor to the audience and stepped aside as the curtains parted. Revealed on stage were a 32-piece orchestra and Macy Teetor spotlighted at the organ.

Orchestra leader Del Delbridge gave the downbeat and the stirring strains of "Hail To The SAE" filled the huge auditorium.

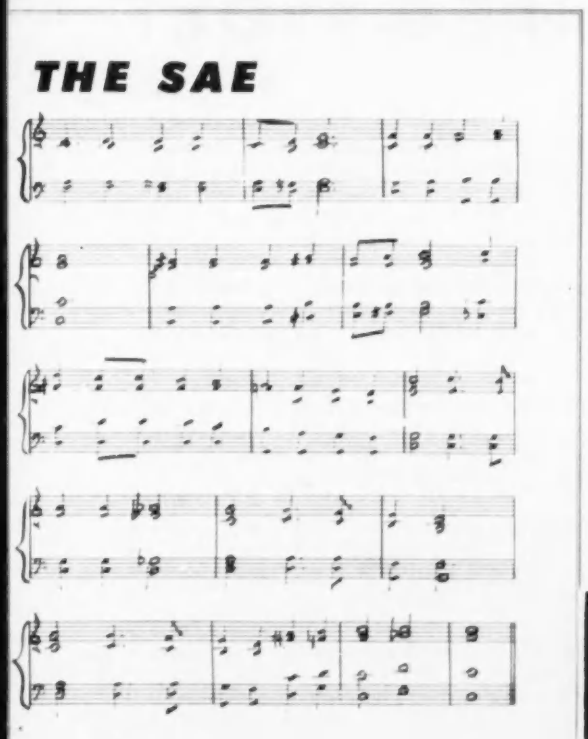
For a second chorus, with lights dimmed, Teetor carried the melody alone, the orchestra providing a soft background accompaniment. Then, going into the third refrain, the orchestra crescendoed, and from overhead a large blue and gold Golden Anniversary Emblem descended. The impressive emblem was fitted with lights that flashed on and off while the orchestra played.

As the final bars of the vigorous march were reached, the footlights came up, and Teetor and the orchestra joined in a crashing finale. Amid thunderous applause Teetor bowed off, and the premiere performance of SAE's new anthem became history.

Teetor says he tried to reflect the Society's vigor and harmony in his composition. The result seemed to appeal to the members, for when they filed out at the end of the program, orchestra and organ were joined by a spontaneous chorus humming tum-tum-ti-tum-tum-tum to the catchy tune.

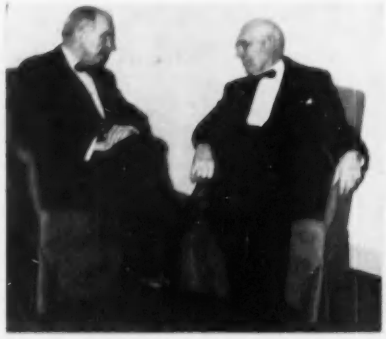
"Hail to the SAE" is not Teetor's first musical success. Back in the 1930's he wrote a melody which attracted the attention of song writer Johnny Mercer, who provided lyrics for it. Their joint product was the hit "Lost."

Teetor is a director of The Perfect Circle Co. He has been chairman of SAE Indiana Section and a national vice-president representing the Fuels and Lubricants Activity. He is a brother of Ralph Teetor, who was SAE president in 1936.

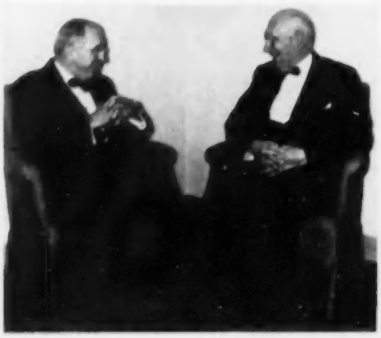


REHEARSING THE ORCHESTRA is Virgil Davis, a Fred Waring arranger, who was engaged to orchestrate the SAE march

Kettering Previews Speech for D. G. Roos . . .



KET: "The Second Law of Thermodynamics simply says in mathematical terms that you can't push on something that is going faster than you are."



ROOS: "I remember your telling me that you can't hatch an egg twice as fast by putting two hens on it."

KET: "Logic is an organized procedure for going wrong with confidence and certainty."

Kettering Looks at "The Next

THE automotive accomplishments during SAE's first 50 years are proof that imaginative engineering will do more over the next 50 years than we can even conceive of now, said Dr. C. F. Kettering at the Golden Anniversary Banquet. In introducing Kettering, SAE Past-President D. G. Roos, cited Boss Ket's unusual ability to shed light on engineering confusion. Kettering spiced his predictions with pungent views on many subjects.

On horsepower: In 1905, the year SAE was founded, the United States had 1,000,000 installed automotive horsepower. In 1955, the industry plans to build 6,000,000 new passenger cars which—giving a liberal fifty percent discount for the misrepresentation of advertising—means 600,000,000 new horsepower to be turned out this year. So, we are in the power industry, plus.

On the self-starter: When I first demonstrated my self-starter a gentleman got up and interrupted me. He said, "Mr. Chairman, this speaker doesn't know a thing about electrical engineering. He has profaned every fundamental law. No wonder his self-starter works."

On standardized procedure: To get out of the groove of a standardized procedure is one of the most difficult jobs in the world. You never can tell when some fellow who doesn't know what he can't do will jump the track.

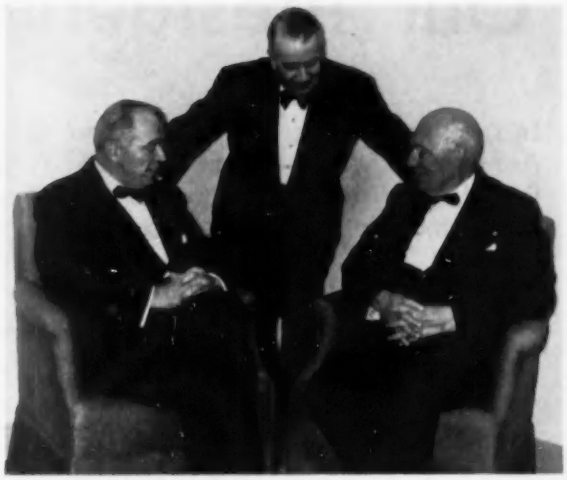
On the tubeless tire: The rubber tire is the basis of our industry. We started with the tubeless tire and now we've gone around in a full circle and are back to it.

On experimental engineering: When someone tells me that an idea won't work I say, "I'll bet you four dollars it doesn't work the way you think it won't." You've got to get a model and try it out.

On atomic energy: It's extremely difficult to find out something about atomic energy. That's because the only things you don't know are the ones that are classified, so you can't find them out.

On lead time: The automobile industry is like the five, six, or seven-year salmon. If we don't put out the kind of hatch now that we should, in seven years from now we are not going to have the kind of things we want.

and John A. C. Warner



KET: "I am not against advertising, but when you want the truth, you've got to take the garnish off."

50 Years"

Combustion efficiency is just the measure of how hot you can get the gas above the piston when it is on the expansion stroke.

On great inventions: I don't think we have made any great inventions yet. Perhaps the wheel is the greatest. But nobody can say what some inventor will do because we have a lot of young fellows who haven't been able to get an education and are quite brilliant. Maybe the next great invention will be the development of a process for turning carbon dioxide into food independently of plants.

On tool making: One of the greatest things that has ever happened in manufacturing—the art of making tools, and having them ready at a fixed time—was made possible by the yearly model change of automobiles. Today your changeover time is very, very short compared to what it used to be. They try the stuff out and they know it is going to work before they put it into production.

Predicting the future: In plotting the future of the industry, if you consider all the factors, use the best extrapolations you can, push it as high as you can, and if you live to see it accomplished, you will be amazed that you missed it so far.

Our Presidents

In summing up the past year, at the Annual Business Session, 1954 SAE President William Littlewood said, before introducing his successor:

"As I have traveled about and met with the members at National and Section meetings, there has been impressed upon me the completeness and diversification of automotive engineering as represented by them in the affairs and activities of SAE. It is certainly true that the Society deals with all aspects of automotive engineering on the ground and in the air; and sometimes on and under the sea. I have not been surprised, therefore, to find all types of engineers working together in SAE—to their own and their profession's benefit, and to the great good of their industries and their country.

"My conviction has grown throughout the year that the strength of SAE lies in the quality of its membership far more than in its ever-growing numbers, and in the active participation of these members in the technical and fraternal exchanges which characterize committee and meeting work.

"We do, however, need more executive sponsorship. We need more of the men who constitute our engineering leadership to become SAE members so that they may better encourage participation by their companies and their personnel. Individual members can help the Society by making their engineering executives aware of their eligibility."

In conclusion, Littlewood extended his thanks "to all the SAE committees everywhere, and all who have worked on them.

"And I wish particularly," he continued, "to thank all members of the Society for their patient understanding and support throughout the year. It has all added up to a wonderful and rewarding experience as your President. I am proud to pass on our 1954 record to my successor."

WILLIAM LITTLEWOOD, 1954 SAE President, spoke at the Annual Business Session (see text above), was master of ceremonies at the Golden Anniversary Banquet, presided at the last meeting of his 1954 Council, and brought a final message to many administrative committee meetings convened during the week.

SAY . . .

Speaking of his coming year of office and the years ahead of that, 1955 SAE President C. G. A. Rosen said in his acceptance speech at the banquet:

"The future of our economic supremacy may soon rest upon the creative ability of our engineers, rather than upon the rich natural resources we once possessed.

"We know that ingenuity has flourished best in democracies where the urge to try has gone hand in hand with freedom. We must see that this continues. We must not let liberty breed laxity nor apathy sap the creative power of our people.

"Creative thinking, the clean urge to seek new knowledge, the sympathetic appreciation of imaginative scholarship—these can be ours and these SAE must steadfastly sponsor as our vital economic resource."

SAE's basic mission in life is, he said, service to its members through the channels of cooperative effort. The automotive industry and the whole country depend on the Society for the technical cooperation it provides through its standardization activities and its information-disseminating meetings and publications.

In order to continue to render this service and to do a better job of it, the Society needs the "talents, efforts, and devotion of its individual members," Rosen emphasized. Pledging to do his part as President, he said, "I hope to be fully aware of the responsibilities which this position of leadership thrusts on me, to the end that your confidence in me may never be impaired."

He paid tribute to 1954 SAE President William Littlewood for the achievements he fostered during his term of office and to all the other hard-working members who have persevered in "bringing our Society to its present high point of eminence in the engineering world."

C. G. A. ROSEN, 1955 SAE President, accepted his new responsibilities in a talk at the Golden Anniversary Banquet (see text above). He presented the Meeting's first technical paper on the first day, presided at the first meeting of his new Council on the last day, and visited numerous administrative committee meetings

PRESS

AT PRESS CONFERENCE, J. M. Campbell, of GM Research Laboratories, brings reporters up to date on industry efforts to combat air pollution in Los Angeles

PREVIEW OF FUTURE aircraft powerplants was given to the press by P. B. Taylor, who presented a paper on the subject at the Wednesday afternoon session

TAPING A RADIO BROADCAST for Detroit station WWJ, Merrill Horine, a member of SAE's 1955 Council, reviews SAE activities of the week. Also interviewed (over WJR) was Ray Faller, 1954 Student Committee Chairman, who told of the Society's interest in student engineers and the close cooperation between SAE and universities

Nation's Press Covers 50th Anniversary Meeting

MORE than 70 reporters and editors, representing more than 50 newspapers, magazines, and broadcasting stations, attended the SAE Golden Anniversary Meeting. As one news syndicate writer said, "The public wants to know what's going on in the automotive industry."

Presence was rewarded by several news "breaks" such as the announcement that the Ford Motor Co. had assembled an experimental gas turbine engine. Also high on the list of news items was the Air Pollution Symposium which opened the evening sessions on Monday, January 10th.

Throughout the week, news of the SAE Meeting was broadcast on radio or television every day. In addition to local radio and television coverage, the SAE Golden Anniversary was acknowledged on a nationwide radio network by Henry J. Taylor, who devoted his entire program to the SAE. The Ed Sullivan Show also saluted SAE's birthday on CBS-TV.

JUDY McCORMICK

ARRIVAL OF THE LETTERS was an open secret, even to Judy, who previews some of them

. . . honored by members and Council at the start of her second 45 years of unique service to the SAE.

Just before the Golden Anniversary meeting, hundreds of letters poured from the hearts of SAE members into the heart of Judy McCormick, who 45 years ago joined the SAE staff as one of three employees.

The letters expressed, both in content and in volume, the unique position she holds as the symbol of all that has made the Society great.

"A glowing personalization of that spirit of goodwill which is the essence of cooperative professional effort" is the way one long-time member characterizes Judy. . . . "Much of the success of our organization has been due to your unselfish effort throughout these years," another tells her. . . . Still another, who typified the thought behind the nearly 500 remarkable personal messages, summarizes with: "Well done, Judy . . . with best wishes for many more years of the same fine associations with you in an activity without parallel in professional organizations."

At the meeting itself, SAE Council, by formal resolution, voiced its similar appreciation for Judy's unique position in the fabric of the Society. It spoke on behalf of the entire membership.

In addition, the Council offered specific and suitable recognition in the form of an increment added to the normal provisions for her retirement some years hence.

To the thousands of SAEers who have basked in Judy's special combination of graciousness and efficiency, the celebration of her 45th anniversary ranked equally with the Golden Anniversary celebration of the Society itself. In their hearts each of them echoed the closing expression of one letter which read:

"May this be the beginning of another 45 years of continued achievement."

REPRESENTING the Council in the presentation of the book of letters were D. P. Barnard, C. G. A. Rosen, and William Littlewood

EIGHT-PANEL DISPLAY EXHIBITED AT MEETING TOLD STORY OF SAE STANDARDIZATION WORK

Technical Board Events . . .

. . . enhance celebration of SAE Fiftieth Anniversary

AMONG the highlights of SAE's Golden Anniversary celebration were the activities of the SAE Technical Board and its committees. Particularly noteworthy were the presentation of certificates of appreciation (see next page) and the Board's display (see above).

The annual Technical Board luncheon had two new features this year. First, certificates of appreciation were awarded to 30 members of technical committees in recognition of their outstanding contributions to SAE technical committee work. 1954 Technical Board Chairman W. M. Walworth presided at the presentation ceremony. He was assisted by 1954 SAE President Littlewood and 1955 SAE President C. G. A. Rosen. This recognition program was started last year.

1955 Technical Board Chairman C. A. Chayne extended a welcome to former Board members who attended the luncheon.

The Technical Board display pointed up typical contributions of SAE standards and specifications to ground vehicle and aircraft engineering.

'55 TECHNICAL BOARD CHAIRMAN C. A. Chayne (right) shows Technical Board display to Board member **B. B. Bachman.** Chayne pointed out that the first SAE Handbook was published in 1910, the year Bachman joined the Society. Bachman was SAE President in 1922, has served the Society in almost every important technical and administrative post. He has been SAE Treasurer since 1943

'54 Technical Board Chairman W. M. Walworth (right) looks over the certificates of appreciation just before the luncheon at which they were presented to the following 30 members of SAE technical committees in recognition of their outstanding contributions to technical committee work:

Gustaf Carvelli
Committee E-27, Splines and Serrated Couplings, of the SAE Aeronautics Committee

T. P. Chase
SAE Brake Committee

James D. Clark
Committee E-25, Engine and Propeller Standard Utility Parts, of the SAE Aeronautics Committee

Gilmoure N. Cole
Committee E-25, Engine and Propeller Standard Utility Parts, of the SAE Aeronautics Committee

William J. Cumming
SAE Transportation and Maintenance Technical Committee

Robert G. Cummings
SAE Screw Threads Committee

Paul V. Faragher
SAE Non-Ferrous Metals Committee

Lester J. Henderson
Committee A-3, Aircraft Fittings and Flexible Hose Assemblies, of the SAE Aeronautics Committee

William S. James
SAE Fuels and Lubricants Technical Committee

J. B. Johnson
Aeronautical Material Specifications Division of the SAE Aeronautics Committee

Oliver K. Kelley
SAE Hydrodynamic Drive and Transmission Committee

Raymond D. Kelly
SAE Aeronautics Committee

Otto E. Kirchner
Committee S-1, Aeronautical Drafting Manual, of the SAE Aeronautics Committee

Harry B. Knowlton
SAE Iron and Steel Technical Committee

Raymond P. Lambeck
Committee P-6, Propeller Standards, of the SAE Aeronautics Committee

Fred B. Lautzenhiser
SAE Transportation and Maintenance Technical Committee

William C. Lawrence
SAE Aeronautics Committee

Kenneth G. Mackenzie
SAE Fuels and Lubricants Technical Committee

Fred Elmer McCleary
SAE Iron and Steel Technical Committee

J. L. McCloud
SAE Fuels and Lubricants Technical Committee

William P. Michell
SAE Truck and Bus Technical Committee

Chester E. Mines
SAE Aeronautics Committee

Emil F. Norelius
SAE Construction and Industrial Machinery Technical Committee

Val J. Roper
SAE Lighting Committee

Robert B. Schenck
SAE Iron and Steel Technical Committee

Bernhard Sterne
SAE Spring Committee

B. R. Teree
Committee A-6, Aircraft Hydraulic and Pneumatic Equipment, of the SAE Aeronautics Committee

T. E. Wagar
SAE Electrical Equipment Committee

Harold S. White
SAE Engine Committee

Wayne H. Worthington
SAE Tractor Technical Committee

MAKING THE

START

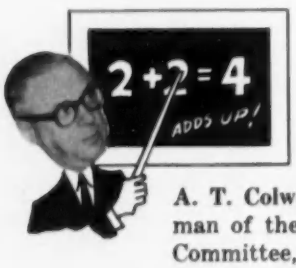
Up bright and early

Technical Board Chairman, **C. A. Chayne** presides at first 1955 meeting as new and revised SAE reports are approved

William Littlewood turns over leadership of SAE Council to **C. G. A. Rosen**

H. L. Hemmingway, 1954 Chairman presides as Placement Committee reviews its overall operating policies for first time in 7 years. **A. C. Hoffman** is 1955 Chairman

Chairman of the Meetings Committee **H. E. Chesebrough** looks into next year's plans



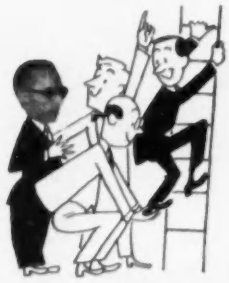
A. T. Colwell, Chairman of the Finance Committee, adds up finances for the Council

ROUNDS

OF THE ADMINISTRATIVE COMMITTEES

C. G. A. Rosen making the rounds of Administrative Committee meetings

Chairman W. J. Lee of the Membership Committee points out that membership gets higher and higher every year

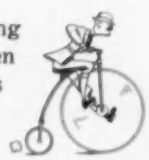


Student Committee Chairman **R. L. Kirkpatrick** hears from **Lee Aldinger** of GMC that students who join technical societies are given a big boost to success

At Sections Committee Meeting, Chairman **Leonard Raymond** surveys section growth during the past year

FINISHED!

D. P. Barnard becomes Chairman of the Past Presidents Advisory Committee. He was awarded a life membership in SAE upon completing his term in the Council as a Past President



Shuttling between hotels

MEMBERSHIP INFORMATION
1905 GOLDEN ANNIVERSARY 1955
1
2
3
4
5
6
7

1. **ADEQUATE REGISTRATION FACILITIES** permitted handling of SAE's largest Annual Meeting attendance with no unusual congestion. Registration desks were operated at both the Sheraton-Cadillac and the Statler. Shown here is part of the Statler operation when the Golden Anniversary Annual Meeting was opening on Monday morning.

2. **THE ANNUAL BUSINESS SESSION** of the Society was held as usual prior to the technical session on Tuesday evening. 1954 President William Littlewood presided. Chief agenda item was announcement of officers elected for 1955. SAE Secretary and General Manager John A. C. Warner (right) read the results. In the middle is SAE Past President A. T. Colwell, who chairmanned the technical session which followed.

3. **APPRAISING AND PRAISING** the handiwork of emblem-designer William Power (right) is Sections Committee Chairman Leonard Raymond. The wall banner shown in this picture was prepared for SAE Section use. Power saw his contest-winning design for the SAE Golden Anniversary emblem reproduced in many other forms for decoration at the Golden Anniversary Annual Meeting.

4. **A SURPRISE SALUTE** was given to M. D. "Doc" Gjerde (second from right), chairman of the SAE Fuels and Lubricants Technical Committee since 1949, by his Committee members. Highlight of the event was the presentation of a diploma conferring upon Gjerde the degree of "Doctor of Conventium."

5. **THE SPEAKERS' TABLE** was just about to be seated at the Golden Anniversary Banquet when this picture was flashed. Nearly 2700 members and guests were at the dinner.

6. **P. M. HELDT** shows his son Walter the plaque he received as the representative of SAE's pioneer members at the Golden Anniversary Banquet (see page 109).

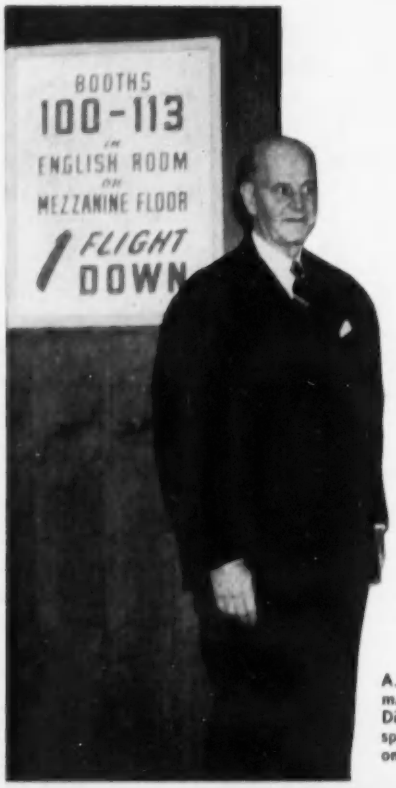
7. **RECEPTION FOR SPEAKERS' TABLE GUESTS** brought together many of the chief executives of the automobile and aeronautic industries, important military and governmental personnel, and 18 of SAE's 23 living Past Presidents.

CHAIRMEN . . .

. . . at Golden Anniversary Annual Meeting technical sessions

- **R. D. Kelly**
  United Air Lines, Inc.
- **A. G. Berg**
  International Civil Aviation Organization
- **C. L. Hecker**
  The Oliver Corp.
- **R. J. Woods**
  Bell Aircraft Co.
- **John Dickson**
  Detroit Diesel Engine Division, GMC
- **F. A. Robbins**
  Koppers Co., Inc.
- **J. M. Campbell**
  Research Laboratories Division, GMC
- **A. E. Lombard**
  U. S. Air Force
- **P. A. Miller**
  Ford Motor Co.
- **Leonard Raymond**
  Socony-Vacuum Oil Co.
- **J. F. Kunc, Jr.**
  Standard Oil Development Co.
- **A. T. Colwell**
  Thompson Products, Inc.
- **G. W. Newton**
  ARO, Inc.
- **T. P. Wright**
  Cornell Aeronautical Laboratory, Inc.
- **R. F. Kohr**
  Ford Motor Co.
- **W. M. Holaday**
  Socony-Vacuum Oil Co.
- **J. O. Sibley**
  U. S. Fidelity and Guaranty Co.
- **H. L. Brock**
  Ford Motor Co.
- **H. S. Kaiser**
  Pontiac Motor Division, GMC
- **F. K. Glynn**
  American Telephone and Telegraph Co.
- **H. L. Willett, Jr.**
  Willett Truck Leasing Co.
- **G. M. Buehrig**
  Ford Motor Co.
- **E. S. Rowland**
  Timken Roller Bearing Co.
- **W. P. Eddy, Jr.**
  Pratt and Whitney Aircraft Division, United Aircraft Corp.
- **R. C. Wallace**
  Diamond T Motor Car Co.
- **R. C. Norrie**
  Kenworth Motor Truck Co.

76 Exhibitors Engineering



A. G. Herreshoff, chairman of the Engineering Display Committee, inspects the display, held on two floors of the Sheraton-Cadillac

Zollner Machine Works
Cleveland Graphite Bronze Co.
Aluminum Co. of America
Ross Gear & Tool Co.
American Bosch Division, American Bosch Arma Corp.
Cities Service Petroleum, Inc.
Continental Motors Corp.
Dualoc Drive, Inc.
Gemmer Mfg. Co.
Brush Electronics Co.
Lord Mfg. Co.
Fram Corp.
Vickers, Inc.
CEC Instruments, Inc.
Detroit Aluminum & Brass Corp.
Auto Specialties Mfg. Co.
Aluminum Industries, Inc.
Le Roi Co.
Koppers Co., Inc.
Aeroquip Corp.
Waldes-Kohinoor, Inc.
Johnson Bronze Co.
Cummins Engine Co., Inc.
Monroe Auto Equipment Co.
Torrington Mfg. Co.
Pierce Governor Co., Inc.
Groov-Pin Corp.
Schwitzer-Cummins Co.
Oil Hydraulics Division, Webster Electric Co.
Garlock Packing Co.
E. I. du Pont de Nemours & Co.
Automotive & Marine Products Corp.
Engineering Castings, Inc.
Perfection Stove Co.
Sparton Automotive Division, Sparks-Withington Co.
Kelsey Hayes Wheel Co.
Anchor Coupling Co., Inc.
Heli-Coil Corp.

Show Wares at Display

Bendix Aviation Corp.
Waukesha Motor Co.
Automotive Rubber Co., Inc.
Leece-Neville Co.
MB Mfg. Co., Inc.
Buda Co., Division of Allis-Chalmers Mfg. Co.
Titeflex, Inc.
S. Sterling Co. (for Allen B. DuMont Laboratories)
Link Engineering Co.
Wayne Engineering Research Institute
Wallace & Tiernan Inc.
Dow Chemical Co.
Bohn Aluminum & Brass Corp.
Lisle Corp.
Rubber Chemical Division, E. I. du Pont de Nemours & Co.
General Plate Division, Metals & Controls Corp.
Spencer Thermostat Division, Metals & Controls Corp.
McCulloch Motors Corp.
Flex-O-Tube Division of Meridan Corp.
Fulton Sylphon Division, Robertshaw-Fulton Controls Co.
Spicer Mfg. Division of Dana Corp.
Hughes Aircraft Co.
Victor Mfg. & Gasket Co.
Stewart-Warner Corp.
Hercules Motors Corp.
G. H. Leland, Inc.
Lincoln Engineering Co.
Mitchell & Smith
Detroit Controls Corp.
Danielson Mfg. Co.
Performance Measurement Co.
Taylor Dynamometer & Machine Co.
International Research & Development Corp.
Haskelite Mfg. Corp.
Kysor Heater Co.
Rosan, Inc.
Sonotone Corp.
Kolene Corp.

Knowledge Unlocks

CUMULATIVE awareness of "what we don't know" was the catalyst behind the growth of the technology encompassed by SAE during its first 50 years . . . and will be for the next 50. Automotive engineers pretty well proved that in their week-long technical output at the SAE Golden Anniversary Annual Meeting.

Automotive technology advances by creating a realization of new areas of ignorance, they said. Over the broad gamut of interests—ground vehicles, aircraft, materials, and manufacturing—engineers echoed a common plaint. It's this: No sooner do we find a key to open one door to an unknown then we're faced with more new doors to unlock.

So automotive engineers see a pretty busy future for themselves stemming from the challenges from this one-step-forward-two-steps-backward pattern.

The need to know what they don't know seems to grow out of three general causes, according to discussions at technical sessions. They are:

1. Human Frailties: Man-made machines are on the threshold of exceeding capacities of the human body to cope with them.

2. Advent of New Technologies: The gas turbine and atomic energy unveiled new areas of darkness.

3. Normal Dissatisfactions: Discontent of engineers with the status quo furnishes the drive to boost the performance of their machines.

Man, the creator of automotive machines, has become the weak link in the operation of the mechanism. Meeting conferees pointed to numerous instances where the device has outstripped the capacities of the human who operates it or is served by it. Airplanes fly too fast and too high. Jet engines raise a din exceeding the human ear's tolerance threshold. And combustion products are more than irritating people, particularly in the Los Angeles area.

While man's physical facilities may no longer suffice, his mental capacities are still required to control and direct the machine. So design engineers face a new unexplored region . . . adapting their machines to human physical capacities.

Take airplane landing speeds, for instance. With approach speeds of about 110 mph, a pilot can make a pretty good landing when breaking out of an overcast with a 200-ft ceiling. But if the airplane is approaching at 140 mph, there just isn't enough time unless it's perfectly lined up when it breaks out of the overcast. Result: a missed approach and the pilot has to make another try.

Instruments are not yet perfected to where they permit a fully automatic approach and landing. So even though plane speeds are going up, engineers will have to figure out ways of cutting approach speed. Boundary layer control shows promise of doing this. But it's a little known concept that engineers don't fully understand.

The human being also proves a hindrance at high-speed, high-altitude flight, especially when he has to escape from a disabled plane. A man parachuting out above 40,000 ft faces death from freezing (temperatures are about – 100 F), demise from shock in opening his 'chute because he'd fall at such high speeds, and destruction from high-velocity air at plane speeds above 500 mph. Only now are engineers beginning to realize how little they know about escape-equipment technology.

Human ears are rebelling against the deafening din from jet-powered aircraft. Aircraft ground crews as well as residents near airports are complaining bitterly about it. The current inability to remedy the situation points up a brand new area for engineering exploration . . . attenuation of gas turbine noise under airplane landing and take-off conditions.

Eye irritations from air pollution in the Los Angeles area is another case in point of community pressure. Here too engineers are taking stock of possible causes and are discovering how little they know. An accusing finger has been pointed at industry, oil refineries and motor vehicles. Hydrocarbons in gases from these sources are said to be largely responsible. To render these hydrocarbons inert and harmless, engineers find they must uncover many unknowns about the chemistry of combustion.

This "jetomic" age has made the automotive scientist suddenly aware of how limited is his comprehension of scientific truths. The atomic bomb and the gas turbine threw light on vast areas of technical darkness.

Overwhelming problems as well as immense po-

Doors to New Unknowns

Discovery of Technical Voids is Springboard to Automotive Progress, Engineers Suggest at GA Annual Meeting

tentials face users of nuclear materials and their radioactive byproducts. One atomic scientist at the meeting reported that he and his colleagues are just beginning to discover what new technologies must be created to build an atomic power industry. He said in part: "We need to know more about corrosion under the influence of nuclear radiation. We will need to explore entirely new fields of metallurgy."

When Commodore Whittle's gas turbine was announced to the engineering world, many raved about its *simplicity* as compared with the piston engine. Today the turbine no longer is a simple machine. Many agree that engineering ignorance has spawned the turbine's complexity.

The compressor blade metallurgical dilemma is just one of the many unsolved turbine puzzles. The higher the hardness of one blade material, the greater the fatigue strength. But lowering the hardness improves the damping capacity. So here are two of the most important compressor blade properties at opposite ends of the hardness range. Should compressor blades be hard or soft?

New engineering fronts are unfolding in the more conventional engineering fields too. They grow from the natural bent of designers to get just a little more work from each pound of material, a bit more power from each cubic inch of displacement.

The search for material-saving techniques has brought into sharp focus the field of residual stresses. But as one specialist in the field said: "Our knowledge of the measurement and effects of residual stresses in general engineering applications not only needs clarification, but also is essentially very meager."

(Following are highlights from the technical papers presented at the Meeting. The papers will be handled more fully in forthcoming issues of SAE Journal.)

Fuel Needs of Civil Aircraft Turbines

TCA Chooses JP-4

Trans-Canada Airlines has chosen JP-4 wide-cut fuel over kerosene for its forthcoming turboprop Viscounts. Basis of the choice: JP-4 is safer in the air because of its higher spontaneous ignition temperature, lesser tendency to creep, and -76 F freeze point. True, JP-4 is more volatile than kerosene, but latest NACA tests indicate that this doesn't materially affect the crash fire hazard. JP-4 has 18,875 Btu per lb—an advantage over kerosene's 18,550 Btu per lb. And JP-4 happens to average 1.5¢ per Imperial gal less than kerosene.

. . . **Paul E. Lamoureux, Trans-Canada Air Lines**, "Commercial Turbine Fuels —An Approach to Their Selection."

Choice Narrows to 3

During the past year, choice of fuel for domestic airline turbine engines has narrowed to three: kerosene, JP-1 (a low freezing point kerosene), and JP-4 (military jet fuel). The petroleum industry is able and willing to supply any of them.

Kerosene and JP-4 will cost about the same in a given area. West Coast prices for the two will be somewhat higher than Gulf Coast prices. JP-1 will be the highest priced of the three.

. . . **E. J. McLaughlin and J. A. Bert, California Research Corp.**, "An Oil Company's Viewpoint on Civil Aircraft Turbine Fuels."

Jet Fuel Specs

There are only six fuel properties which aircraft turbine engine manufacturers feel must be controlled. These six are: volatility, viscosity, heat of combustion, specific gravity, corrosivity, and foreign material content.

. . . **H. A. Fremont and E. V. Albert, General Electric Co.**, "Must Jets Be Pampered?"

Turbine Fuels

Kerosene and the other heavy turbine fuels are attractive from the fuel-cost standpoint. But airframe builders

figure that any fuel heavy enough to require heating in the airplane tanks will lose much—if not all—of its cost advantage.

Whatever the fuel is, it must be carefully quality-controlled and carried in worldwide supply.

. . . **C. A. Weise, Douglas Aircraft Co., Inc.**, "An Airframe Manufacturer's Viewpoint on Civil Aircraft Turbine Fuel"

Small Engines

In Europe, where the economic incentive for the diesel is much greater because of higher fuel costs, small engines are likely to be diesels anyway.

Over here the choice between gasoline, lpg, and diesel engines of small size is appreciably affected by their initial costs and thus by the differential costs of the accessories, among which the injection pump is the biggest item.

It is only logical that inherently less expensive single-plunger pumps have been under intensive development in America.

. . . **S. E. Miller and T. D. Hess, American Bosch Division**, "Diesel Injection System with New Features."

International Air Coach Agrowing

International first-class air traffic may be reaching some sort of limit, but international air coach is increasing terrifically.

When we remember that it places a two-week vacation abroad within the reach of people of modest income, it is believable that international air coach will continue to grow, subject only to the vagaries of world economic and political conditions.

. . . **Carlos Wood, Douglas Aircraft Co., Inc.**, "Present Trends and Future Possibilities in Air Transportation."

Detergents

Detergents which are effective at high engine temperatures are not necessarily effective at low engine temperatures. The performance of detergents in low temperature engine service is believed to be related to their sensitivity to water. . .

. . . **R. L. Willis and E. C. Ballard, E. I. duPont de Nemours & Co.**, "The Control of Low Temperature Sludge in Passenger Car Engines."

Aircrew Escape

It seems that aircrew escape is a grisly subject better described in terms of its hazards and failures than by its successes. But improvements in speed and altitude of aircraft go hand in hand with increases in difficulty of escape from them.

As new safety equipment is developed to overcome these difficulties, it becomes heavier and bulkier. This hinders performance, so we find that if the ejection seat is insufficient for safe escape, a capsule may be too heavy.

We are faced with a dilemma . . . that we can avoid only through increased powerplant efficiency, greater knowledge of fluid dynamics, and intensified research into escape equipment technology.

. . . **William Bonas and M. J. Reilly, Glenn L. Martin Co.**, "That First, Long Step—Problems of Aircrew Escape."

Piston Ring Wear

It's possible to measure piston ring wear by use of irradiated piston rings and geiger counter without disassembling the engine. Dust particles which are very hard cause high initial wear and a continuing higher-than-normal wear rate, indicating that they remain intact as long as they are in the engine. Particles of softer materials appear to be disintegrated during the initial wear process and become incapable of causing further wear.

. . . **C. E. Watson, F. J. Hanly, and R. W. Burchell, California Research Corp.**, "Abrasive Wear of Piston Rings."

Civil Turbine Power

We will need at least two groups of civil turbine power; one for the domestic intercity airplane, providing power up to 2000 ehp (equivalent horse power); and another for the big transcontinental and transoceanic airplanes with power to at least 6000 ehp.

Perhaps two types will actually be required of the latter, with powers up to 5000 ehp for the mainline transcontinental and at least 8000 ehp for the transoceanic.

. . . **J. T. Dyment, Trans-Canada Airlines**, "Airline's Viewpoint of Status of Turbine Era."

Jet Fares

The high-speed jet transport airplane shows substantially less direct operating cost than existing transport types. It could be operated at present-day fares at substantially greater profit per passenger-mile flown and per dollar invested.

. . . **G. S. Schairer, Boeing Airplane Co.**, "Economic Considerations of a Jet Transport Airplane."

Fuel Composition

Increasing fuel volatility by the elimination of high boiling materials reduces the fuel contributions to octane requirement increase. As the use of volatile fuels and multi-viscosity lubricants becomes more general, it should be possible to increase compression ratios without a corresponding increase in antiknock quality. . .

. . . **C. L. Fleming, Jr., N. V. Hakala, L. E. Moody, R. W. Scott, and C. O. Tongberg, Standard Oil Development Co.**, "Control of Engine Knock Through Gasoline and Oil Composition."

Convertible Aircraft for Combat

In every great conflict in the world, some major development is more or less responsible for victory. We have already seen in Korea the important role that the helicopter played in the rescue and reconnaissance service.

Little consideration has been given to the requirements and the effects of the development of medium-sized convertible aircraft for combat services. The effect of such a realistic development could easily be such a big improvement in the tactical Air Force and the airborne Army that 10 divisions airborne by convertiplane would equal 25 conventional infantry divisions.

. . . **E. Burke Wilford, Pennsylvania Aircraft Corp.**, "Convertible Aircraft Art."

Planning Military Aircraft

The military planner is one of the most harassed individuals of our society. As a rule, he needs and welcomes the help of industry.

The aeronautical industry should participate in this fundamental planning.

Modern weapons demand a combination of technical "state-of-art," national policy, operational feasibility, and knowledge of future technical possibilities. None of these can be successful without a reasonably accurate scientific consideration of all the others.

. . . **R. P. Buschmann, Lockheed Aircraft Corp.**, "Planning for Best Airplanes."

Vapor Lock and Fuel Volatility

Reid vapor pressure alone is not an adequate procedure for controlling the vapor locking tendencies of highly volatile gasolines. In fact, some gasolines of normal vapor pressure have a higher vapor locking tendency than some gasolines of above normal vapor pres-

sure. Since a few car models are exceptionally prone to vapor lock, a more careful fuel system design is required to use economic fuels.

. . . **D. P. Heath, R. H. Thena, Socony-Vacuum Oil Company,** and **G. Way Ethyl Corp.**, "Passenger Car Vapor Lock."

Automation's Ultimatum

In the big economic picture, the economics of automation are harsh, but simple: automate or die.

. . . **W. C. Newberg, Dodge Division, Chrysler Corp.** "The Economics of Automation."

3 Do Work of 29

Ten years ago 29 separate machines would have been required for certain drilling and inspection operations on our automotive crankshafts. Today the same department requires only three transfer-type machines of eight stations each.

. . . **G. G. Murie, Ford Motor Co.** "Automation and Its Requirements"

Atomic Energy Potential

Out of 68 industrial companies engaged in atomic power development only one is a representative of the automotive industry. . . . By 1985 the capacity of nuclear power plants will be as large as our conventional capacity today—430 billion kilowatts.

. . . **A. Tammaro, U. S. Atomic Energy Commission,** "The Potential Contribution of the Automotive Industry to the Field of Atomic Energy."

Gas Turbine

The key to the achievement of a successful automotive gas turbine power plant is the development of high efficiency, broad range components and effective regeneration. Gasoline fuel economy is very poor for a vehicle powered by a simple gas cycle turbine operating at the relatively low turbine inlet temperature of 1600 F, and a pressure ratio of 4:1. On the other hand, if a regenerator with high effectiveness is added to a simple gas cycle gas turbine, the fuel economy is greatly improved.

. . . **A. H. Beaufrere, Ford Motor Co.**, "An Exploration of the Automotive Gas Turbine."

NiO Film Cuts Friction

Certain nickel alloys sliding on steel wear better at 1000 F than at room temperature. NACA research indicates that the reason is that the higher the temperature, the more readily the nickel alloy forms a nickel oxide film. The soft oxide smeared over the hard matrix apparently serves as a good lubricant.

Indications are that nickel alloys may be superior materials for the cages of rolling-contact bearings for turbine engines.

. . . **R. L. Johnson and E. E. Bisson, Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics,** "Bearings and Lubricants for Aircraft Turbine Engines."

Air Pollution Problems

Hydrocarbon Tonnage

In 1953 there were 2,211,600 automobiles and trucks in Los Angeles County consuming 4½ million gallons of gasoline daily. Exhaust gas analyses obtained while driving under moderate traffic conditions indicate that about 1200 tons of hydrocarbons enter the atmosphere each day from automobiles.

. . . **G. P. Larson, J. C. Chipman, E. K. Kauper, Air Pollution Control District, Los Angeles County,** "A Study of Distribution and Effects of Automotive Exhaust Gases in Los Angeles"

Pollution Sources

The major source of air pollution in Los Angeles County is the incomplete combustion of over 50,000 tons of organic materials and fuels each day by the general public and industry. In addition to aldehydes, ammonia, and oxides of nitrogen and of sulfur, 440 tons of hydrocarbons are evaporated into the air each day. About half comes from the production, manufacture, and distribution of petroleum products, the other half from the evaporation of gasoline from service stations and autos.

. . . **D. H. Hutchison and Francis R. Holden, Stanford Research Institute,** "An Inventory of Automobile Gases."

SCAPF—What It Is

In November of 1953, a group of about 100 civic and business leaders founded the Southern California Air Pollution Foundation, an independent scientific organization supported by public-spirited citizens to help determine the causes of smog and implement its elimination. Its program includes informing the public periodically concerning the nature and extent of air pollution, progress made in its elimination, and obstacles to such elimination.

. . . **W. L. Faith, Southern California Air Pollution Foundation,** "SCAPF—What It Is and What It Does."

Ozone Formation

Automobile exhaust gases are capable of forming ozone in the air, and are therefore one definite source of smog. The formation of ozone can be duplicated in the laboratory by exposing hydrocarbon vapors and nitrogen oxides to sunlight.

. . . **A. J. Haagen-Smit, California Institute of Technology,** and **Margaret M. Fox, L.A. County Air Pollution Control District,** "Automobile Exhaust and Ozone Formation."

Eliminating Hydrocarbons

Although it is still impossible to eliminate all the unburned hydrocarbon emission during all driving conditions, it is possible to reduce it. This can be done by admitting additional air and fuel to the intake manifold during deceleration, or by shutting off the fuel during deceleration.

. . . **J. T. Wentworth and W. A. Daniel, Research Laboratories Div., General Motors Corp.**, "Flame Photographs of Light Load Combustion Point the Way To Reduction of Hydrocarbons in Exhaust Gas."

Hydrocarbon Content

A substantial reduction in the average hydrocarbon content could be obtained by adjustment of the idle mixture ratio of all cars to the range resulting in best idle operation. Hydrocarbon content increases sharply to high values at manifold vacuums above 21 inches of mercury. . .

. . . **F. G. Rounds, P. A. Bennett, and G. J. Nebel, General Motors Corp.**, "Some Effects of Engine-Fuel Variables on Exhaust Gas Hydrocarbon Content."

"Soft" Blades for the J-47

GE now hardens its AISI Type 401 stainless compressor blades to 20-26 Rc instead of to over 32 Rc. The increase in damping capacity outweighs the lower fatigue strength. Also, the softer blades have better stress-corrosion resistance, better impact strength, and are easier to heat-treat and machine. They save at least $50 per engine and appear to have reduced incidence of blade failure by 75-85%.

. . . **E. M. Phillips and R. E. Weymouth, General Electric Co,** "Jet Engine Compressor Blades—Hard or Soft?"

Plastic Blades

We can now produce glass-fiber reinforced plastic compressor blades capable of withstanding 500 F. Soon we expect to make experimental plastic blades that will withstand 700 F. Dimensional control is excellent. Creep is negligible. And strength-to-weight ratio of the reinforced plastic is about three times that of compressor blade steel.

. . . **A. T. Colwell, Thompson Products, Inc.,** "The Manufacture of Blades, Buckets, and Vanes for Turbine Engines."

Jet Test Cells

Cell configuration can affect measured jet engine thrust. Cell-to-cell variations are caused principally by entrainment of different amounts of fresh air in the jet stream This can account for 2-3% differences in the measured thrust of a given engine.

. . . **R. J. Vannelli, Ford Motor Co.,** "Turbojet Engine Test Cell Design and Correlation."

New Chevrolet V-8 Engine

The new Chevrolet V-8 engine develops 162 gross hp at 4400 rpm, and has a gross torque of 257 ft-lb at 2200 rpm. Bmep is 146.0 psi at 2200 rpm. Specific fuel consumption is 0.498 lb per hp-hr. Total weight of the engine is 531 lb, compared to 572 lb for last year's Six.

. . . **F. F. Sanders, Chevrolet Motor Div., General Motors Corp.,** "The New Chevrolet V-8 Engine."

New Pontiac V-8 Engine

The Pontiac V-8 engine has a 3.75 in. diameter bore, 3.25 in. stroke and 287 cu in. displacement. A 12-v electrical system has been adopted. At -10 F a 12-v starting motor gives 16% faster cranking speeds than a 6-v motor of the same size. A maximum full throttle horsepower of 180 bhp is attained at 4600 rpm. Maximum torque is 264 lb-ft at 2400 rpm.

. . . **C. B. Leach and E. L. Windeler, Pontiac Motor Div., General Motors Corp.,** "The New Pontiac V-8 Engine"

Fatigue Strength

Through a range of soft to medium hardness steels, increase in fatigue strength is roughly proportional to the increase in surface hardness readings. In parts such as gears, ball bearings, or springs, which are left very hard by heat treatment, other factors no doubt play a relatively greater role.

. . . **C. W. Gadd, J. O. Anderson,** and **D. Martin, Research Laboratories Div., General Motors Corp.,** "Some Factors Affecting the Fatigue Strength of Steel Members."

Selecting Fleet Cars

Don't forget about resale values when you're considering the economic side of selecting passenger cars for fleets. It often pays to choose the deluxe model instead of the standard, the 8-cylinder instead of the 6-cylinder, the four-door instead of the two-door, the two-tone instead of the usual black or maroon. The fancier cars cost a little more new—but their higher resale value more than makes up for that, in many cases.

. . . Round Table on Selection of Passenger Cars for Fleet Operation—**J. O. Sibley,** panel leader, **U. S. Fidelity and Guaranty Co.; M. K. Simkins** secretary, **"Commercial Car Journal"; W. H. Langseder, Thomas J. Lipton, Inc.; A. C. Schmidt, Armour and Co.; G. E. Wilson, Lever Brothers Co.; C. A. Bateman, Bateman Motors Ltd.**

Plastics for Truck Bodies

Thermoset Plastics

These are the qualities that make polyesters and epoxies so suitable for truck bodies:

1. They are compatible with fibrous glass reinforcement, which is very strong.
2. They may be catalyzed to produce a cure, thereby obviating use of outside heat.
3. They can be molded with reinforcement at low pressures and, in many cases, on low-cost tubes.

. . . **Hiram McCann, "Modern Plastics" magazine,** "The Across-the-Board Look at Plastics for Truck Bodies"

Plastic Truck Tanks

Glass-fiber reinforced plastic is an excellent material for the fabrication of light-weight, corrosion-resistant, durable liquid transport tanks. Most plastic tanks built so far have been layed up by hand. But matched-die preformed section assembly gives better appearance, greater chemical and moisture resistance, higher strength, and lower weight.

. . . **D. S. Brown, Brodix Corp.,** "Use of Reinforced Plastics for the Construction of Transport Tanks"

Plastic Trailer

We are producing a new refrigerated trailer that has plastic skins and also reinforced plastic structural members. Each member carries its load and also serves as a spacer between the inner corrugated plastic and the outer smooth skins. The space between them takes the insulation. The sub-frame composed of plastic cross members and insulation is sandwiched between aluminum extruded flooring and plastic sheets.

. . . **S. S. Wulc, Strick Co.,** "Plastics for Trailer Bodies"

20 Plastic Trucks Ordered

We have one pilot-model plastic parcel delivery truck in service and 19 more being built. Here are some of the advantages we see to plastic bodies for our trucks: potentially reduced capital investment, lighter weight, less fender and body damage, better appearance, heat insulation, translucency for skylights, and shape design freedom.

. . . **W. R. Herfurth, United Parcel Service,** "Fiber Glass Reinforced Plastic Door-to-Door Delivery Truck Bodies."

Easy Repair

When we assigned an editor to do a story on repair of plastic bodies, he couldn't find a damaged panel—damage is that rare, even in the shop of a large plastics fabricator. What the editor saw after he had a plastic panel deliberately punctured convinced him that plastic is as easy—if not easier—to repair as any body material.

. . . **Henry Jennings, "Fleet Owner" magazine,** "Plastic Bodies Can Be Repaired."

Symbolic Auto

The automobile has become the symbol, all over the world, of American industrial genius and enterprise. (This is one invention even the Russians haven't had the nerve to claim.)

It is so potent a force that it is very nearly the symbol of American thought and morals to people who don't know us. It is more than an object to be sold for money. The automobile is an American cultural symbol.

. . . **Raymond Loewy, Raymond Loewy Associates,** "An exploration of the Future of Automobile Bodies."

Management and Creativity

An engineering manager who, because of the business demands of his job fails to sponsor enthusiastically or support actively a good new idea conceived in his organization, will suffer the loss of enthusiasm and devotion so essential to a creative organization.

This manager fails to represent and he likewise fails to use his organization. Because of business demands upon the creative manager, this is probably the greatest weakness in our creative organizations. . . .

. . . **E. S. MacPherson, Ford Motor Co.,** "The Challenge of the 2005 Car."

Residual Stress Measurement

There now exists an expanding urge both in industry and in universities to investigate new methods of residual stress measurement, to improve current methods, and to determine exactly what is being measured.

The establishment of SAE Division IV—Residual Stresses in 1953 represents an expression of this concerted interest of industry and universities to understand and to be able to control residual stresses in engineering applications.

. . . **J. A. Halgren, T. C. Huang, and E. I. Blount, International Harvester Co.,** "Measurement of Residual Stress in Review."

Nonstrategic Alloy

GMR-235 is a high-temperature alloy that has a strategic alloy rating of only 306—as compared with 364 for Nimonic 80 and 849 for Inconel X. It takes a stress of 34,000-41,000 psi to produce a rupture in 100 hr at 1500 F. Composition is: carbon, 0.10-0.20%; manganese, 0.25% maximum; silicon, 0.60% maximum; chromium, 14.00-17.00%; iron, 8.00-12.00%; molybdenum, 4.50-6.0%; aluminum, 2.50-3.50%; titanium, 1.50-2.50%; boron, 0.025-0.100%; nickel, balance.

. . . **D. K. Hanink, F. J. Webbere, and A. L. Boegehold, Research Laboratories Division, GMC,** "Development of a New Gas Turbine Super Alloy GMR-235."

ALDIP Improves Values

General Motors' ALDIP treatment increases the durability of certain intake valves by at least 100% under design conditions. Valves can be processed by the ALDIP technique without excessive distortion if they are stress-relief annealed or relatively free from straightening stresses. The process does not require increased use of strategic elements.

. . . **R. F. Thomson and D. K. Hanink, Research Laboratories Division of GMC, E. B. Etchells, Chevrolet Motor Division, and K. B. Valentine, Pontiac Motor Division,** "Engine Valves Improved by ALDIP Coating."

Vehicle Suspensions

Residual Stress Effects

The effects of residual stresses primarily depend on their magnitude at exposed surfaces. Therefore, whenever residual stresses are referred to, without further specification, these surface stresses are implied.

Generally, residual tensile stresses at the surface are damaging, while residual compressive stresses are beneficial.

. . . **George Sachs, Syracuse University,** "Control of Residual Stresses in Practice."

Residual Compressive Stresses

Improvements in fatigue strength are being obtained by the use of favorable residual compressive stresses produced by thermal methods. Of particular interest is the method of producing these stresses by water quenching from the tempering temperatures used in conventional heat-treating procedures. . . .

. . . **O. J. Horger and H. R. Neifert, Timken Roller Bearing Co.,** "Correlation of Residual Stresses with Performance."

Air Spring Suspensions

Since 1936, a hundred or more experimental installations, many thousands of bus and several thousand military application miles have demonstrated the outstanding new suspension performance that may be accomplished when light-weight, low-cost, highly elastic, easily controlled air is used as the elastic medium to support the load on the vehicle axle or wheel structure.

. . . **Roy W. Brown, Firestone Tire & Rubber Co.,** "Air and Heavy Vehicle Suspensions."

Rubber Springs

There has been a tendency to try to make rubber springs conform to limitations set up for other type spring means. It is obvious that the best results can be had only where the design is carried out without excessive reference to the limitations of other springs.

. . . **A. S. Krotz, B. F. Goodrich Co.; R. E. Houser, Flexible Co.; and J. H. Kramer, B. F. Goodrich Co.,** "Self-Leveling Torsilastic Suspension."

Liquid Springs

It has been repeatedly demonstrated that liquid springs, because of the extremely small mass piston member, operate at much higher frequencies than mechanical springs.

This is borne out by many tests, particularly of a liquid spring built within an Ordnance device.

Operation was equivalent to firing a shell in a gun and catching it before it left the barrel, with a liquid spring storing this energy. Associated with the mechanism was a coil spring operating at 50% of the velocity of the liquid spring. The initial and last coil of the coil spring stretched from the acceleration and deceleration forces, respectively, and the liquid spring performed satisfactorily.

. . . **Paul H. Taylor, Wales-Strippit Corp. and Taylor Development Co.,** "Liquid Springs in Vehicle Suspensions."

About SAE Members

P. L. HOUSER has joined the staff of the Metal Cutting Tool Institute. He was general supervisor of manufacturing standards at International Harvester Co. Houser resigned his chairmanship of SAE Sectional Committee B5, Small Tools and Machine Tool Elements. However, he will continue to maintain his membership on the Committee as SAE representative. Houser received the ASA Standards Medal in 1953.

DR. C. O. TONGBERG has been appointed vice president of Standard Oil Development Co. He has also been named to the executive committee and elected a director. He had been serving as coordinator of product research and development.

Tongberg

Rogers

ROBERT P. ROGERS has been appointed superintendent of the Missile Experimental Shop of the Missile Section, Bendix Products division, Bendix Aviation Corp., Mishawaka, Ind. He was previously project engineer in charge of production design activities with Bendix.

STUART G. BAITS, general manager of the Hudson Special Products Division of American Motors Corp. and a vice-president of American Motors, will serve on the new policy board of that company. Other SAE members to serve on the board are **E. W. BERNITT**, vice-president in charge of manufacturing and procurement for the automotive division, and **B. A. CHAPMAN**, vice-president and general manager of the autonomous Kelvinator division.

RICHARD S. HUXTABLE, who resigned last July as president and a director of Federal Fawick Corp. (now Fawick Corp.), has been elected president and treasurer of three firms and a board member of another company.

He now heads Cleveland Detroit Corp.; Cleveland Lathe & Machine Co.; and a new firm, Morrow Products, Inc., developer of electrical and electronic equipment, which also will serve as the research affiliate of the other firms.

Huxtable was named a director of Telectron, Inc. in addition. His headquarters will be in the Cleveland Lathe & Machine plant.

FRANK H. RIDDLE, vice-president, Champion Spark Plug Co., Detroit, has been named 1955 recipient of the Albert Victor Bleininger Award. This award is the highest honor conferred in this country for distinguished achievement in the field of Ceramics and is given annually by the Pittsburgh Section of the American Ceramic Society.

GEORGE J. TOTH has resigned his position as eastern representative with the Harnischfeger Corp. He has been appointed vice president of the Atlantic Equipment Co., Inc. of Readville, Mass., who are engineers, designers and manufacturers of diesel and gasoline driven generator sets, pump units and marine auxiliaries.

STEVEN B. WILSON has retired as president of Fram Corp., East Providence, R. I. However he remains as chairman of the Board of Directors of that corporation.

RUSSELL G. RILEY of Thompson Products, Inc., has been presented the Distinguished Service Award of the Philadelphia Advisory Committee for State Highway Inspection. The plaque recognized "his outstanding foresight and personal efforts in promoting and producing the film on Pennsylvania inspection system, resulting in a major contribution to highway safety."

Heinemann

Kindelberger

EDWARD H. HEINEMANN, chief engineer, El Segundo Plant of Douglas Aircraft Co., and **JAMES H. KINDELBERGER**, chairman of the board of North American Aviation, Inc., have been presented the 1954 Collier Trophy by President Eisenhower. The trophy was awarded for "the greatest achievements in aviation in America."

Heinemann was cited for development of the carrier-based F4D, the Skyray. Kindelberger received the award for his work on the land-based F-100, the Super Sabre.

WILLIAM P. BALTHROP has become quality inspection supervisor for Chrysler Corp. Balthrop entered the Chrysler Institute of Engineering in 1944 and since May last year has been a staff engineer at the Jefferson plant.

JOHN G. BANNISTER has been elected to the newly-created post of first vice president, National Automotive Fibres, Inc., Detroit. Bannister, who is also a director, was formerly vice president in charge of manufacturing.

FRANK G. WOOLLARD of Birmingham, England, has written a new book, "Principles of Mass and Flow Production." The author, who has 30 years experience in large-scale flow production, shows how its basic principles can be applied to the manufacture of most high-production items. He has included chapters on both automatic transfer machines and the automatic factory. The book contains 196 pp., 102 illustrations. Publisher is Iliffe & Sons, London.

THOMAS J. CARMICHAEL has been named by **C. A. CHAYNE**, vice-president in charge of engineering, General Motors Corp., to represent him as engineer in charge of Field Investigations. Carmichael, who was formerly administrative engineer at the General Motors Proving Ground, Milford, Mich., has been active in SAE technical committee work, being chairman of the Society's Front Wheel Alignment Committee and its representative on ASA Sectional Committee D7 on Standards for the Safety Inspection of Motor Vehicles. He also has been an active member of the Winter Driving Hazards Committee of the National Safety Council and of committees of the Highway Research Board.

Continued on page 174

from the Sections

Personalities in the spotlight at Section meetings . . . 1954 SAE President William Littlewood presents a basic concept in the problem of aircraft fatigue before Washington Section. Four Washington Section members are honored with 25 Year Membership Certificates. Buffalo is host to A. T. Colwell, 1941 SAE President, speaking on "Old and New in the Automotive Industry." 25 Year Membership Certificate is presented to Wichita notable. Northwest welcomes a new SAE student club. Ralph P. Horan of Detroit receives the Henry Ford Memorial Award for his paper "Overhead Valve Gear Problems." Attendance prize given by St. Louis to Section Past Chairman Roy Adolphson. Western Michigan gives out 25 Year Membership Certificates.

Kansas City

Field Editor
P. L. Dumas
Nov. 11

THE CATALYTIC CRACKER AT SUGAR CREEK REFINERY was one of the chief points of interest in the tour experienced by members and guests, Nov. 11.

Following dinner, the group went to the machine shop area and inspected the various machines, pipe threading and bending equipment, and welders. They then returned to the dining area for a movie showing the chemical processes involved in the production of gasoline, fuel oils and end products as now being used in the modern refineries.

The manager of the Sugar Creek Refinery gave a talk covering the history of oil refining and a discussion of how the crude oil is brought into the plant and the products are distributed to outlying territories. He also told of the plant capacities and the provisions of water supply.

Members and guests were then split into groups of ten or twelve and Standard Oil guides conducted them through the laboratories in the Administration Building and through several of the larger new units on the west side of the plant area. This part of the tour was especially interesting, showing the **catalytic cracker, regenerative units, control panel rooms, compressors** and **power rooms.**

Field Editor
P. L. Dumas
Dec. 14

THE STORY OF A DUAL PURPOSE PLANT unfolded for Kansas City Section as they toured the Buick-Oldsmobile-Pontiac Assembly Plant of General Motors Corp.

John Gretzinger, chief engineer of BOP and vice-chairman of the Section, welcomed members and guests. Then E. D. Rollert, plant manager of BOP, outlined the production and plant arrangement best suited for changing from all-out defense to partial defense and car production, or to full car production; these **changes to be accomplished with the least possible disruption of production or machine moving costs** in this dual purpose plant.

Assisting Rollert in outlining the details and responsibilities of the various departments were

Gretzinger; Darrell Don Carlos, assistant director of quality control; and Thomas Gillespie, chief test pilot.

Colonel Preston Brown of the U. S. Air Force told of the responsibilities of the Air Force in helping the contractor to meet requirements and to see that the product as received by the Air Force meets all specifications and is modified to correct design to conform to service requirements.

—Submitted by A. M. Ernat

Twin City

Field Editor
R. V. Rosenwald
Nov. 23

THE RIGORS OF THE FAR NORTH—snow, dust, wind, and cold—must be considered in the winterization requirements of diesel engine power equipment. A review of those requirements was given for Twin City Section by P. W. Espenschade, consultant, Mechanical Engineering Department, Engineer Research and Development Laboratories, Fort Belvoir, Va.

The men operating the equipment are severely handicapped because of the bulk of winter clothing. They can't hear, have very restricted eyesight, and their hands are like clubs. Ordinary control knobs and handles are too small to be grasped by the boxing glove type mittens. Normal access openings are too small to permit a bulky clothed maintenance man to enter. All these openings must be weather tight, but the job of keeping out the fine, dry, wind-driven snow is not easy. Espenschade said that the way the snow blew into every crack, he figured it would completely fill a room by being blown through a keyhole.

Great strides have been made in preparing for the rigors of the north, but there is still a great deal of improvement needed before operation is satisfactory.

Washington

Field Editor
R. Auburn
Dec. 10

MULTIPLE STRESS PATHS ARE THE ANSWER FOR THE AIRCRAFT FATIGUE PROBLEM according to 1954 SAE President William Littlewood. **The vital structural parts must be constructed of multiple members so that fatigue failures occurring in single members will still enable the load to be carried by the remaining members.** He believes this to be a basic concept or design philosophy for the protection against fatigue failures. In addition, tear stoppers, as well as inspectability and replaceability are essential in all structural design of aircraft.

Littlewood advocates a four engine turbo-prop transport to serve the medium range flight requirements of between 150 and 350 mi. He visualizes an airplane which could start in operation three years from now and be good for at least a ten-year working life. The aircraft should accommodate about 60 people and offer a modest increase in cruising speed of about 10 to 50% over the speed of the current medium range equipment.

For longer ranges he visualizes a turbojet powered aircraft to fly at .8 to .85 mach, to accommodate 80 to 120 persons, operate between 45 and 50,000 ft altitude, and be capable of non-stop coast-to-coast operation. Referring to airframe manufacturers' proposals for these requirements, and to the one existing prototype, Littlewood stated that these designs must be proved from the standpoint of:

(a) the soundness of the economics of the operation,
(b) reliability of the power plant and
(c) the acceptability of the noise level.

Certificates of recognition were presented by Littlewood to four members of the Washington Section who have completed 25 years of membership in SAE. These are: Bernard Benson, superintendent of permits, D. C.; Warren Gilbert, chief, Facilities Branch, Aluminum & Magnesium Division, National Production Authority, Washington, D. C.; Harold Hoekstra, chief project officer, Civil Aeronautics Administration, Aircraft Engineering Division, Washington, D. C.; and Allen Taylor, automotive engineer, (Aviation Refuelers), Department of the Navy, Bureau of Aeronautics, Washington, D. C.

Chicago

Field Editor
Peter Polko
Dec. 14

ENTHUSIASM FOR THE BOEING 707 JET ENGINE TRANSPORT was expressed by personnel of Boeing Airplane Co. in their belief that they had an airplane which was initiating a new future.

Maynard L. Pennell, chief project engineer, Aircraft, Boeing Airplane Co., presented a paper on "Design Considerations of the Boeing 707 Jet Engine Transport." In discussion of overall design, he stated that Boeing's objective was to create a transport which could carry people or cargo more safely, more economically, and faster than existing means of air transportation.

In comparing jet and piston engine transports, Pennell pointed out the following advantages of the jet propelled planes: **greater earning capacity, reduced depreciation, safer power plants,** and **less complex instruments.**

Colorado

Field Editor
P. G. Anderson
Nov. 1

OF PARTICULAR INTEREST TO TRUCKING IN THE ROCKY MOUNTAIN REGION is the paper, "More Payload Through Better Weight Distribution," presented by Merrill C. Horine, consulting engineer. Mack Mfg. Corp.

The very lively discussion period following the

presentation of the paper found some members disagreeing with the statement that fifth wheel location for maximum front axle loading does not effect jacknifing. While complete agreement was not reached on this subject, the facts presented by Horine will be the subject of discussion for some time.

Buffalo

Field Editor
D. I. Hall
Nov. 22

ENGINE DESIGN IS WAY AHEAD OF THE SUSPENSION SYSTEM and the next big advance in automobiles will be in the suspension system. A. T. Colwell made this statement while speaking on the "Old and New in the Automobile Industry." Colwell, vice-president of Thompson Products, Inc. and SAE president in 1941, made some predictions on the future trends in automobiles at the November meeting of Buffalo Section.

Other trends in automobiles will include an increase in the number of "second" cars in families, notably of the smaller, more maneuverable type to cope with the increasing parking problem. **Fuel injection is coming,** especially in crowded metropolitan areas like Los Angeles, where atmospheric conditions are favorable to the formation of "smog." We might even expect diesel (with turbo superchargers) powered cars in the future. Other features that will be pronounced will be **advancements in power steering, brakes and jacking systems.**

Colwell stated that he fully expected that by 1960 or 1965, a production of 7,000,000 cars a year would be achieved.

In reply to the question "What about turbines?", Colwell listed the problems of initial cost, service training, and necessary metallurgical developments as contributing to place the turbine 5 to 15 years in the future.

The finest tribute that the automotive engineer receives is a silent one—"because people look at the car, and don't even look under the hood; they take the dependability of the mechanism for granted."

Indiana

Field Editor
M. B. Emig
Nov. 18

HIGHWAYS WHICH WILL STEER THE CAR IF THE DRIVER HAS A MOMENTARY LAPSE are in the plans for the future. The highway of the future, complete with built-in safety and riding comfort, was described by Philip Pretz.

Pretz, executive engineer of Ford Engineering Staff's vehicles testing office, spoke on safety factors in automotive and highway design in relation to growing traffic problems.

"We expect some day to see highways where drivers are encouraged to travel in the proper speed lanes because it will require continuous effort for them to do otherwise—highways which will steer the car if the driver has a momentary lapse—where curves, rises and dips cannot be felt because they are designed below the limits of our sensitivity," he said.

Pretz told about Ford's plans for developing its new Michigan Proving Ground at Romeo, Mich., near Detroit, and said the construction may influence future public highway design. **"Pavement geometry"** will be applied in the banking of curves at the proving ground so that test drivers can negotiate the turns as fast as present-day or future cars can travel.

The automotive engineer has contributed importantly to safety on the highway. He listed improvements in driver visibility and lighting through development of greater glass areas, uniform sealed-beam headlights, directional signals and more prominent tail lights.

Independent front suspension systems have made steering safer; tire and brake improvements have shortened stopping distances; increased power has improved passing performance; and comfort considerations have reduced driver fatigue.

The automobile industry takes a keen interest in the nation's highway problems and contributes financial and technical assistance in the study and development of highway needs and policies.

"The motor vehicle is only a part of the total transportation system, and an adequate road system, a sound regulatory framework and driver education programs are also necessary," he said.

Wichita

Field Editor
G. W. Jones
Dec. 20

BLIND FLYING WHILE HOVERING NECESSITATES NEW INSTRUMENTS FOR THE HELICOPTER. Charles Siebel brought out this fact in his paper on the development of the Cessna Helicopter. As long as forward speed is maintained, the present instruments are satisfactory. Problems of approval testing were stressed and a comparsion of the design of the helicopter and small aircraft was made showing their similarity as well as their differences.

Walter Burnham, chief, tool design, Boeing Airplane Co., received his SAE 25 year Membership Certificate. He had held all elective offices in the local Section and takes a very active participation in local and national SAE affairs.

Northwest

Field Editor
S. J. McTaggart
Dec. 10

APPLYING COATINGS OF TUNGSTEN CARBIDE TO METAL PARTS, Linde Air Products Co.'s new Flame-Plating process, has the major advantage of

low temperature deposition. Temperatures of the base piece rarely exceed 400F during the plating operation. This reduces to a minimum the chances for distortion or change in the properties of the base metal. For this reason, Flame-Plating is well suited for use on finished or semi-finished precision parts.

George B. Ray, Linde's Pacific Coast engineering representative, also pointed out that the modulus of elasticity of flame-plated tungsten carbide is surprisingly low, being approximately 27,000,000 lb psi as compared to 85 to 90,000,000 lb psi for sintered tungsten carbide. There is some thinking in the industry that materials with a low modulus have a higher resistance to frictional and abrasive wear, because even a light load will cause a slight deflection of the coating. This will distribute the load over a larger portion of the bearing surface prolonging the wear life of the part.

The Northwest Section extends its best wishes for the future growth and success of the new student club being formed at Seattle University. Professor Francis J. Smedley is serving as Faculty Advisor.

Northern California

Field Editor
R. E. Van Sickle
Nov. 17

BY 1960 50% OF THE TOTAL OPERATING COST FOR DIESEL LOCOMOTIVES WILL BE SPENT IN FUEL and the railroads will require 50% of the nation's diesel fuel production. Paul V. Garin of the Southern Pacific Co. stressed these facts in explaining the interest in "Economy Fuels For Diesel Locomotives" at the Section's Diesel Meeting.

Garin reviewed the highlights of Southern Pacific's work seeking substitutes for first line diesel fuels. Their experience included handling and utilizing experimental and economy fuels having **viscosities of 72 SSU at 100F, 230F flash points, low cetane ratings,** and **relatively high sulfur and ash contents.** These fuels were evaluated in full-scale tests in locomotives equipped with special filters and fuel heaters. Under heavy duty mountain service, freight locomotives were able to reduce fuel consumption by 3% using low American Petroleum Institute gravity fuels. Based upon the results of such tests, an economy fuel has been adopted as a standard fuel by the railroad.

Field Editor
C. F. Carey
Dec. 7

AIR SPEEDS OF UP TO 2600 MPH will be developed in the test section of the new trans- and supersonic wind tunnel now nearing completion at Moffett Field's Ames Aeronautical Laboratory.

216,000 hp, developed by four 54,000 hp motors, **will drive an axial flow compressor** in the tunnel. J. Lloyd Jones, chief of the Ames Laboratory Supersonic Wind Tunnel Division, reported this and other interesting facts to members and guests of the South Bay Division at the Dec. 7 meeting. National Advisory Committee on Aeronautics researchers will be able to explore problems hitherto beyond the capacity of wind tunnels.

Earlier in the day a crowd of over 100 toured the laboratory and examined one of the existing tunnels.

Detroit

Field Editor
G. F. Gass, Jr.
Nov. 29

SUSPENSION SYSTEMS FROM A TO Z came into consideration at the third activity of the Detroit Section Junior membership. The meeting consisted of a panel discussion. Three Junior members covered what is needed, what we have, and finally what the ideal system would be. Donald Kinker, project engineer, Chrysler Corp., was moderator.

Nick Baracos, suspension engineer, Lincoln-Mercury Division, Ford Motor Co., said that basic automotive suspension system requirements are **comfort, control,** and **safety,** short of collision.

Philip Bowser, project engineer, Chevrolet Motor Division, General Motors Corp., evaluated the human tolerance limits, from a comfort standpoint, of the various vibrations and their frequencies that could be accepted in suspension systems.

Robert Batchelor, project engineer, Chassis Design Section, Chrysler Corp., emphasized the necessity for understeer and the danger of oversteer. Side loads and their effects were discussed and the aerodynamic stability of present designs were evaluated.

Following the technical papers, Maurice Olley, director of the research and development section, Chevrolet Division, General Motors Corp.; L. H. Frailing, manager of the Packard Proving Ground; and Tines Kennedy, Thompson Products, Inc., joined the Junior speakers for an open consultation period.

Field Editor
W. F. Sherman
Dec. 13

THE NEW CONCEPT OF A "PERSONAL CAR" which might bridge the gap between the standard automobiles and sports car types got top billing at the Detroit Section meeting of December 13. W. E. Burnett, executive engineer of Ford Car Engineering, and F. Q. Hershey, chief of car and truck styling for Ford, were principal speakers.

Burnett showed the evolution of the chassis components and highlighted it with emphasis on the effects of chassis and power plants on the over all performance characteristics. Hershey discussed the origin of the present styling and traced the Thunderbird evolution from pure sports car to the personal car concept. Pictures of the earlier road test versions and of the final result were also shown.

Tying in with the main theme was a presentation by Dr. Walton E. Cole, of the First Congregational Church of Detroit, on the subject "Why I Drive

Sports Cars."

Feature of the meeting was the presentation of the Henry Ford Memorial Award to Ralph P. Horan, chief project engineer, Valve and Saginaw Division of Eaton Mfg. Co., for his paper "Overhead Valve Gear Problems."

Hawaii

Field Editor
F. L. Helbush
Nov. 22

REPORT FOR THE ISLANDS on "The Use and Application of Hydraulic Drives," was presented by R. M. Schaefer, manager of the Transmission Engineering Department, Allison Division of General Motors Corp. Schaefer was brought to the islands to present this same paper to the Hawaiian Sugar Technologists' meeting.

Atlanta

Field Editor
D. J. Tolan
Dec. 6

FREIGHT CAN BE MOVED WITH A DIRECT COST OF 4¢ PER TON MILE BY THE C130 TRANSPORT said Robert W. Middlewood of the Georgia Division, Lockheed Aircraft Corp. Middlewood addressed a record group of 97 at the Atlanta Group meeting Dec. 6.

While transport design has heretofore been occupied with the movement of people, the new Lockheed C130 Hercules has been specifically designed to move cargo and can accommodate such equipment as trucks, bulldozers, and road graders. A loading ramp at truck bed level reduces loading and unloading time thereby reducing indirect freight costs.

To meet requirements as heavy hauler, troop transport, and hospital plane, the C130 was designed for **dependable control and stability at low speeds, increased range-payload capabilities**, and **exceptional take-off and landing performance.**

Middlewood stated that flight tests of the C130, which is now in production in Georgia, have shown performance to exceed their expectations.

Salt Lake

Field Editor
C. W. Dunbar
Dec. 6

CERAMIC LINERS WHICH SHOW NO WEAR ON THE CYLINDER WALL AFTER 7000 HRS OF OPERATION were discussed by Samuel S. Kistler, dean of the College of Engineering, University of Utah. These and many other interesting characteristics of ceramic cylinder liners were considered in his presentation, "Ceramic Cylinder Liners For Internal Combustion Engines," before a joint meeting of the SAE and ASME at the University of Utah.

Speaking of the project begun while Kistler was director of research for the Norton Co., he explained that cast iron or steel, when rubbed against the smooth surface of a dense grinding wheel, would have less wear than when rubbed on a cast iron or steel surface, and also the coefficient of friction would be less. Since **cylinder and ring wear are the most limiting factors in the life of such engines,** it appeared that the use of very hard abrasive materials for cylinder liners might extend cylinder and ring life indefinitely.

These results emanated from the study of abrasives of the glass bonded silicon carbide and aluminum oxide types. Utilizing piston rings of very hard steel and tungsten carbide, these liners were run in a one-cylinder air cooled engine and, later, a Ford V-8 engine and a Hough Payloader. Many hours were run also in tests conducted by the Caterpillar Tractor Co.

Discussion following the talk indicated a keen interest in the research problems arising from the development of these new non-metallic cylinder liners.

St. Louis

Field Editor
Gene Kropf
Dec. 15

THE AERODYNAMICIST HAS MET HIS CHALLENGE in the jet propulsion industry according to J. M. Pederson, manager of marketing at General Electric Co.'s Evendale, Ohio plant.

In his paper, "The Dramatic Achievement of Gas Turbine Engines and Their Impact on Civilization," Pederson stated that the aerodynamicist has been called upon to solve problems that have puzzled engineers for years, and the fact that our present day jet engines are as dependable as they are is a real tribute to his accomplishments. He stressed the point that speed made possible by the jet engine is of utmost importance both from the military and commercial standpoint.

Professor Charles Remington, Jr., vice-chairman of Student activities for the Section and faculty advisor for the Student Branch at the Missouri School of Mining and Metallurgy, provided the after dinner entertainment. He brought the "Varsity Four," a group of talented singers from the Rolla, Mo. campus.

Past chairman Roy Adolphson won the attendance prize of a beautiful pen and pencil desk set presented by the St. Louis Public Service Co.

Metropolitan

Field Editor
Leslie Peat
Nov. 4

FIRST NORTH AMERICAN OPERATOR TO PUT TURBOPROP TRANSPORTS INTO COMMERCIAL

SERVICE will be Trans-Canada Air Lines. The Vickers Viscounts it has ordered will start replacing Canadian built North Stars on TCA's short and medium range routes next spring. TCA's reasons for switching from reciprocating engine transports to turboprops were outlined tonight for members by Gordon R. McGregor, president of TCA, before the first Air Transport Dinner Meeting of the season.

When TCA made its survey of new equipment for its short and medium range Canadian services, there were two aircraft available, a well known American piston-engine twin of modern design and the four turbo-propeller engined Vickers Viscount. Careful study by TCA's technical and flight operations people led to the conclusion that, while there were individual differences in performance between the two aircraft, the aggregate of the technical qualifications of both transports added up to the same. Final evaluation had to be made on the basis of certain intangibles on which a definite dollar sign could not be placed.

Favoring the U. S. built transport were the factors of geographical proximity of the purchaser and the manufacturer and what McGregor referred to as "American gadgetry" with which his airline was familiar. In the favor of the Viscount were the Rolls Royce engines. TCA was particularly predisposed towards Rolls Royce because of the very favorable experience it had with the Rolls Merlin engines in its North Stars. Then the Vickers Co. agreed to TCA's request for several **major modifications in design,** including a completely **new cockpit, redesigned fuel system,** and a completely **new cabin interior,** including heating and pressurization. The final decision was made in 1952, four years after the Viscount prototype first flew, and taken primarily on the basis that the four-engine transport was considered to have a greater margin for safety in the event of an engine failure, and secondly, because the turboprop transport, because of its freedom from vibration, would have greater passenger appeal.

—Submitted by Hugh Harvey.

Western Michigan

Field Editor
W. C. Chaffee
Dec. 8

SINCE THE 40 HP AIR-COOLED ENGINE contributions have steadily been made by Continental Motors Corp. to the aircraft industry. William Wiseman, chief engineer of the Aircraft Engine Division of Continental Motors, reviewed those contributions in his talk before Western Michigan Section members and guests.

Wiseman reminded the audience of their first 40 hp air-cooled engine, which was later supplemented by a 6-cylinder air-cooled engine. The problems in designing a new engine, maintaining interchangeability with old tooling and engine mountings, while still improving performance and reducing frontal area were described at some length.

Improved cylinder construction and a wind-up starter added to a more efficient engine. Requirements for high altitudes were met by the addition of a supercharger and provisions were made for fan cooling when the engine is used in helicopters. Many interesting pictures were shown of the application of various engines in single and multi-engine planes.

SAE 25 year Membership Certificates were presented by Chairman Thomas Reeves, Continental Motors Corp., to H. J. Swanson, Swanson Machinery Co., and C. A. Teichert, Diesel Equipment Division, General Motors Corp. A Certificate was also presented by Reeves to A. H. Frauenthal, Kaydon Engineering Corp., for his 31 years of membership.

Philadelphia

Field Editor
G. T. Seng
Nov. 10

A SPORTS CAR STRICTLY AMERICAN IN DESIGN is the description presented by Wilbur J. Sherrin of the new Ford Thunderbird. Sherrin, assistant chief Ford car engineer, Engineering Staff, Ford Motor Co., revealed some of the design features and performance built into this new concept in American sports cars.

Some of the outstanding features are the **removable hard top, telescoping steering column,** and the short shift lever for standard or automatic transmission, installed in the floorboard in true sports car tradition.

With dual exhaust designed for less hp loss, V-8 engine with four barrel carburetor and standard transmission, the snappy Thunderbird will push 80 mph from standing start in 17.2 sec, according to Sherrin.

Field Editor
G. T. Seng
Dec. 8

EXPERIMENTS IN KNOCK AND ANTIKNOCK ACTION were discussed by Dr. Bernard M. Sturgis, assistant director, Petroleum Laboratory, E. I. du Pont de Nemours & Co.

The occurrence of knock in spark-ignition engines operated on hydrocarbon fuels is controlled by the nature and extent of the preflame reactions which occur prior to fuel combustion, he said.

Although these reactions are very complex, the specific reactions causing knock are believed to be relatively simple, probably involving very fast reactions initiated by species containing only hydrogen and oxygen.

Hydrocarbon structure influences the rate of accumulation of sufficient quantities of the hydrogen-oxygen species to cause knock.

Tetraethyl lead does not affect to any extent the early hydrocarbon reactions, but slows some of the later stages of reaction, possibly by deactivating the hydrogen-oxygen species.

The active antiknock species may be either lead oxide or metallic lead, although experiments seem to favor the former.

SAE

Automotive Ordnance Day

Detroit Arsenal **Centerline, Michigan** **February 28, 1955**

Featuring . . .

"The Next 50 Years of Ordnance"

by Major General E. L. Cummings
Chief of Ordnance, Department of the Army

and

An Inside View of Detroit Arsenal

Discussions by Arsenal Representatives:

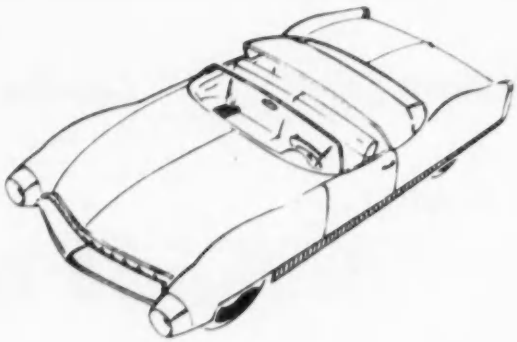
- Arsenal Development Plant—its program and problems
- Military use of titanium
- Air cleaners for automotive vehicles
- Use of automatic computers in vehicle problems

General Tour of Arsenal Facilities

- Materials Laboratory
- Instrument Laboratory
- Electrical Laboratory
- Graphic Laboratory
- Radiographic Laboratory
- Power Plant Laboratory
- Experimental Model Division
- Model Shop
- Demonstration of Analogue Computer Equipment

Luncheon **Detroit Arsenal Cafeteria**

SAE Golden Anniversary National Passenger Car, Body, and Materials Meeting



With the Spotlight on . . .

- Tire Thump
- Body Engineering
- Future Car Styling
- Rubber For Automobile Use
- New Slants on Brake Problems
- Engineering of Camshaft and Tappets

Sheraton-Cadillac Hotel — **Detroit, Michigan**

March 1-3, 1955

SAE Section Meetings . . .

Atlanta—March 7

Ship-a-Hoy Restaurant. Dinner 7:00 p. m., meeting 8:00 p. m. Speaker will be a representative of Chrysler Corp.

Buffalo—Feb. 22

Sheraton Hotel. Dinner 7:00 p. m. Golden Anniversary Meeting. Pinwheels—Gas Turbines—W. A. Turunen, GM Research and Development. Honored Guest—1955 SAE President C. G. A. Rosen.

Canadian—Feb. 23

Royal York Hotel, Toronto. Dinner 7:00 p. m. In Quest of Creativeness—1955 SAE President C. G. A. Rosen.

Central Illinois—Feb. 21

American Legion Hall, Peoria, Ill. Dinner 6:45 p. m., meeting 7:45 p. m. Golden Anniversary Meeting. In Quest of Creativeness—1955 SAE President C. G. A. Rosen. After dinner speaker Rhodell Owen, Director of Peoria Parks.

Chicago—Mar. 8

Hotel Knickerbocker. Dinner 6:45 p. m., meeting 8:00 p. m. Joint meeting of the Fuels and Lubricants and Transportation and Maintenance Activities.

Cleveland—Feb. 14

Manger Hotel, Cleveland. Dinner 6:30 p. m., meeting 7:45 p. m. The Amazing Engineering and Architecture of the Ancient Egyptians—Eric Brater, assistant chief engineer, Cleveland Diesel Engine Division, GMC.

Dayton—Feb. 17

Hotel Van Cleveland. Dinner 7:00 p. m., meeting 8:00 p. m. Automotive Styling—G. T. Christiansen, administrative assistant styling section, GMC.

Detroit—Feb. 21

U. S. Rubber Co. Dinner 6:30 p. m. High Speed Operation of Tires—E. H. Wallace, Associate Director, Tire Development, U. S. Rubber Co. Toastmaster: K. E. Coppock, Fisher Body Division, GMC. Starting at 3:30 there will be a tour of U. S. Rubber Co. tire manufacturing plant and engineering facilities. Student Activity Meeting.

Metropolitan—Feb. 16

The Engineering Societies Building, 29 West 39th Street, fifth floor. Meeting 7:45 p. m. Fuel Injection Development—T. P. Hess, American Bosch Division, American Bosch Arma Corp.

Mid-Continent—Feb. 18

Ponca City Meeting. 7:30 p. m. The Mexican Pan-American Road Race—J. R. Gillette, supervisor, advanced car planning section, Lincoln and Mercury Car Engineering, Ford Motor Co.

Mohawk-Hudson—Mar. 8

Circle Inn, Latham, N. Y. Dinner 6:45 p. m., meeting 8:00 p. m. Magic Barrel—Oil Industries Committee—N. A. Butterfield, district manager, Atlantic Refining Co.

Montreal—Feb. 24

Sheraton Mount Royal Hotel. Dinner 7:00 p. m., meeting 8:00 p. m. Golden Anniversary Meeting. In Quest of Creativeness—1955 SAE President C. G. A. Rosen.

Northwest—Feb. 11

Stewart Hotel, Seattle, Wash. Dinner 6:30 p. m., meeting 7:45 p. m., Trends in Gasoline Quality and Commercial Engine Design—R. E. Gish, assistant manager engine development, Ethyl Corp., Detroit, Mich.

Oregon—Feb. 16

Ione Plaza. Dinner 7:00 p. m., meeting 8:00 p. m. Trends in Gasoline Quality and Commercial Engine Design—Rollin E. Gish, assistant manager of Engine Development, Ethyl Corp.

Philadelphia—Mar. 9

Engineers' Club. Dinner 6:30 p. m., meeting 7:30 p. m.—Thumbing Through An Engineer's Notebook—1955 SAE President C. G. A. Rosen. Presentation of 25 and 35 year Certificates.

Pittsburgh—Mar. 1

Webster Hall — Mellon Institute. Dinner 6:00 p. m., meeting 8:00 p. m. New Developments in Tires—W. H. Elliott, field engineering department, B. F. Goodrich Co., Akron, Ohio. Motion pictures of tire testing will be shown.

Southern California—Feb. 14 & Mar. 14

Feb. 14—Rodger Young Auditorium, Los Angeles. Dinner 6:30 p. m., meeting 8:00 p. m. Physiological Aspects of High-Altitude Flight—Dr. Ulrich C. Luft, Lovelace Foundation, Albuquerque, N. Mex.

Mar. 14—Rodger Young Auditorium, Los Angeles. Dinner 6:30 p. m., meeting 8:00 p. m. Golden Anniversary Meeting. Combustion Chamber Deposits—Influence of Fuels and Lubricants—J. F. Socolofsky and Ralph Albright, fuels and lubricants supervisors, Socony-Vacuum Oil Co., Paulsboro, N. J.

Southern New England—Mar. 2

Hartford. Dinner 6:45 p. m., meeting 8:00 p. m. Engineering Applications of Nickel Plate—James McNally, Bart Products, Newark, N. J.

Spokane-Intermountain—Mar. 10

Caravan Inn. Dinner 7:00 p. m., meeting 8:00 p. m. Piston Rings, Art

Please turn page

or Science—M. E. Estey, chief research engineer, Perfect Circle Corp., Hagerstown, Ind.

Syracuse—Mar. 7

Museum of Fine Arts. Dinner 6:30 p. m., meeting 8:00 p. m. Passenger Safety in Automobile Crashes—E. R. Dye, Head, Industrial Division Cornell Aeronautical Laboratory, Buffalo, N. Y.

Texas—Mar. 11

Trucks & Buses.

Twin City—Mar. 9

Curtis Hotel, Minneapolis, Minn. Dinner 6:30 p. m. Turbocharger Applications in Automotive Use—J. A. Hardy, chief research engineer, Schweitzer Cummins Co., Indianapolis, Indiana.

Washington—Feb. 15

Occidental Restaurant — International Room. Dinner 7:00 p. m., meeting 8:00 p. m. Horizons of SAE—Dr. D. P. Barnard, deputy assistant secretary of Defense (R.&D.), Wash., D. C. Looking to the Future in Aeronautics —Dr. Hugh Dryden, director, NACA, Wash., D. C. Golden Anniversary Meeting featuring Land, Sea, and Air Topics. Special film presentations, "Atom Goes to Sea" depicting the sea wolf story, and "Future of America".

This is not a complete list of all Section Meetings. It includes only those meetings for which we have received sufficient advance notice to permit listing.

SAE GOLDEN ANNIVERSARY

NATIONAL MEETINGS...

February 28, 1955
Automotive Ordnance Day,
Detroit Arsenal,
Center Line, Mich.

March 1-3, 1955
Passenger Car, Body and
Materials Meeting
The Sheraton-Cadillac Hotel,
Detroit, Mich.

March 14-16, 1955
Production Meeting and Forum
Netherland Plaza, Cincinnati,
Ohio

April 18-21, 1955
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering
Display, Hotel Statler and
McAlpin Hotel, New York, N. Y.

June 12-17, 1955
Summer Meeting
Chalfonte-Haddon Hall,
Atlantic City, N. J.

August 15-17, 1955
West Coast Meeting
Hotel Multnomah, Portland,
Ore.

September 12-15, 1955
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee,
Wis.

October 11-15, 1955
Aeronautic Meeting
Aircraft Production Forum,
and Aircraft Engineering
Display
Hotel Statler, Los Angeles, Calif.

October 31-November 2, 1955
Transportation Meeting
The Chase, St. Louis, Mo.

November 2-4, 1955
Diesel Engine Meeting
The Chase, St. Louis, Mo.

November 9-10, 1955
Fuels and Lubricants Meeting
The Bellevue-Stratford
Philadelphia, Pennsylvania

"The SAE Story"

. . . a new history of the Society of Automotive Engineers

CHAPTER I

Fertile Soil and Good Seed

FROM its start in 1905, the Society of Automotive Engineers has been a living organism—growing, changing, adapting itself to altered circumstances even as it contributed to create those circumstances.

The men who pioneered the automobile industry had vision. Those who founded the SAE were endowed most generously with this capacity. But it is doubtful if even they foresaw a fraction of what lay in store. What they did see were immediate needs, problems which they believed could be solved best by joint effort. So they set about to organize the machinery to handle not only pressing needs, but those that would assuredly arise in the future. This was no easy task.

Consider first the industry. It comprised about 125 manufacturers, the majority turning out gasoline-powered vehicles, the remainder steamers and electrics. Formerly they had made stoves, tacks, bicycles, sewing machines, presses, blowers, firearms, trolleys, pumps, buggies, yachts, and shoes. This was the limit of their experience. Their factories were usually machine and carriage shops, and sometimes just a barn.

Production in the year 1905 was about 22,500 vehicles—small by 1955 standards, but substantial for that day. Evidently it was sufficient to press hard upon the undeveloped market and create a temporary unbalance Interestingly enough, the president of the Knox Automobile Co. was then saying:

"There is a limit to the quantity (of automobiles) that this or any other country can absorb, and we are inclined to advise conservatism in the planning of production."

Continued on next page

PRINTED HERE are the first four of the ten chapters of "The SAE Story." This new history tells the story of SAE from its start in 1905 to its Golden Anniversary in 1955.

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Copies of the complete publication (SP-136) are available from SAE Special Publications Department at $2 to SAE members and $4 to nonmembers.

continued from page 143

Sales did have to be fought for. Weak companies fell by the way and the strong crawled over them. Mortality was such that solid bankers, who liked to get in on the ground floor of coming successes, wanted no part in the financing of this industrial folly.

There were no engineering departments as we know them today. Some of the most successful designers operated in more or less free-lance manner, producing designs for one newly organized company after another. It brought them broad experience and a reputation. Some capitalized upon this to establish companies of their own.

What these pioneers produced in the way of a motor vehicle bears little resemblance to the automobile of today. It was ornery in operation, adversely affected by road and weather, and notoriously unreliable. To operate it required some degree of mechanical ability and ingenuity. Motoring, which meant a trip of less than 100 miles, was always a unique experience, appealing to the adventurous and the hardy.

Pioneering is rarely easy and it requires some sustaining idea to outweigh the frustrations and heartaches, to make the struggle worth while. To the farseeing men of the industry, the concept of flexible, individual transportation was sufficient to keep them plugging. They discussed and argued with each other on the relative merits of this and that mechanical feature to the end that the automobile might become a truly reliable vehicle of transportation. They voiced their interests and ambitions in letters to the editors of automobile publications until there crystallized the idea that an organization was needed to provide a forum for engineers. Their attitude was clearly expressed as early as 1902 in an editorial appearing in the June Fourth issue of *Horseless Age*. It read:

> *"Now that there is a noticeable tendency for the automobile manufacturers to follow certain accepted lines of construction, technical questions constantly arise which require for their solution the cooperation of the technical men connected with the industry. These questions could best be dealt with by a technical society. . . . The field of activity for this society would be the purely technical side of automobiles. . . . Meetings could be held at specified intervals, at different places, and papers read and discussed on subjects relating to the branch of engineering which the society represents . . ."*
>
> —PETER M. HELDT

Three more years of discussion, of letters to the press, and of editorials were to follow before the Society of Automobile Engineers became a fact. Later to be renamed the Society of Automotive Engineers, it sprang from the needs and desires of individual engineers, as reflected in trade paper pages and as prompted by their editors and publishers.

Origin of the SAE can be traced directly to an idea conceived by E. T. Birdsall, consulting engineer of New York. Horace M. Swetland, also of New York, publisher of *The Automobile*, gave the idea publicity and so won widespread acceptance for it. Records have it that Birdsall, in the year 1902, suggested to Swetland and A. H. Whiting of Whiting Motors Co., New York, the idea of organizing an automobile engineering society. The three men discussed the proposal among themselves and then with a widening circle of acquaintances. Swetland promoted the suggestion in the columns of his publications and advocated immediate organization to the engineers who attended the early New York automobile shows.

While it met with general approval, the proposal did raise some questions. Why form another engineering society when there were long-established ones in existence? Would engineers be able to cooperate now that the industry had become so highly competitive? What about the Association of Licensed Automobile Manufacturers, which included engineering among the activities of its Mechanical Branch?

To many engineering minds the need for an organization was not vitiated by such questions. Established engineering societies, they protested, regarded automobile engineering as faddish. The ALAM was said to smack of industrial sales promotion and politics. What the engineers insisted upon was a new technical society, dedicated exclusively to automobile engineering, receptive to new ideas, alert to progress, and free of all commercialism.

Birdsall explained later that he sought to make Swetland his first convert because of the publicity outlets afforded by the Swetland publications. This objective gained, Birdsall resigned from numerous societies and clubs to devote his time and energy to organizing automobile engineers. He defined these men, not entirely facetiously, as "all those who recognize an automobile on Fifth Avenue at sight."

In 1903, Birdsall wrote to men prominent in the industry advocating the formation of a society whose membership would embrace engineers of the entire industry rather than be drawn from one group, as were the members of the ALAM, the Association of Licensed Automobile Manufacturers. Among those so solicited were H. W. Alden and Hiram P. Maxim, both of the Electric Vehicle Co., Hartford; Henry Ford; Andrew L. Riker of the Locomobile Co. of America; and A. H. Whiting.

Shortly thereafter an informal meeting was held at the Automobile Club of America, attended by six of the men to whom Birdsall had written. Here the decision was reached to form a society. Then followed other meetings devoted to preparing a constitution and bylaws which would incorporate the good and exclude what they considered the unfortunate features of existing technical societies.

By the end of November, 1903, sufficient progress had been made to justify sending out a second letter, this time calling for a meeting during the week of the 1904 New York Automobile Show for the express purpose of completing the formal organization of a society of automobile engineers.

In retrospect the organization of the Society appears to have proceeded very smoothly, but that is not a fact. Birdsall's idea was not received with unanimous approval. Engineers had plenty of doubts and raised embarrassing questions. Would experienced engineers share their knowledge willingly? Could trade secrets be discussed? Were all engineers sound and practical in their thinking? Would a new organization be preferable to affiliation with established technical societies? Could such a society be financed?

Birdsall was not one to be

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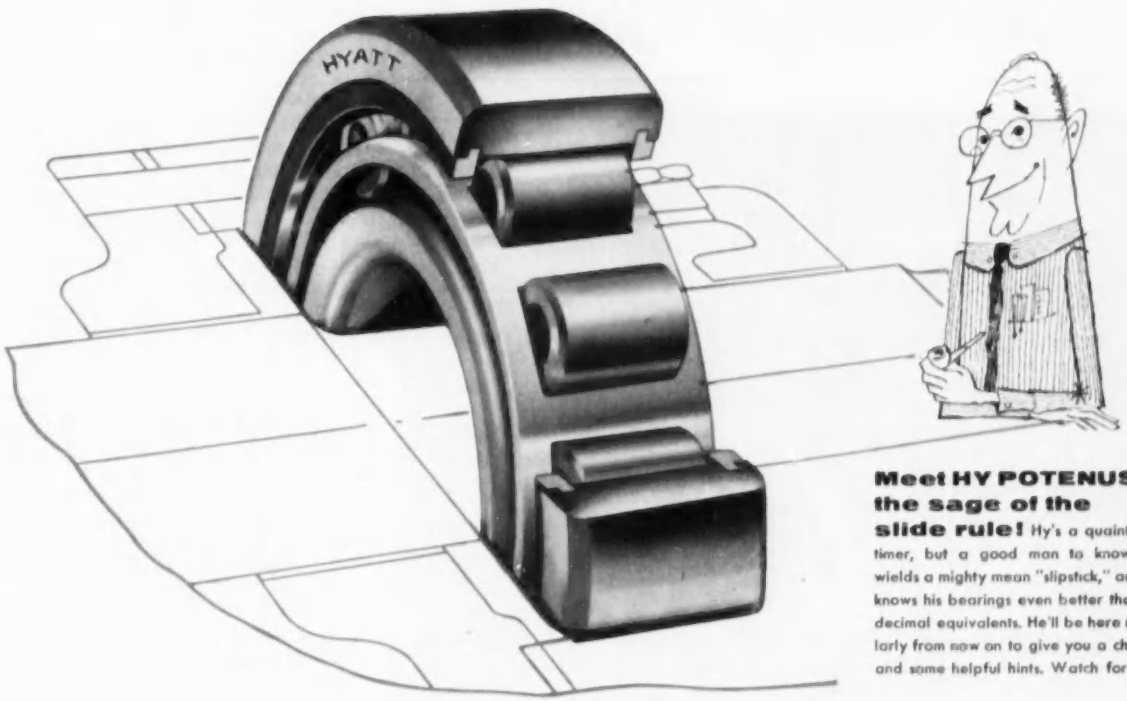

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downed by the skeptics and on Jan. 18, 1904, a meeting was held at the Hotel Navarre, New York, at which a preliminary organization was effected. A. L. Riker was elected president, and Birdsall was given the post of secretary-treasurer. Birdsall, Whiting, and Swetland were appointed a committee to devise a suitable name for the organization and to complete the drafting of a constitution and by-laws providing for membership, officers, dues, governing board, as well as to work out principles and policies of operation.

The first formal meeting of the Society took place in New York in January, 1905, and the following officers were elected:

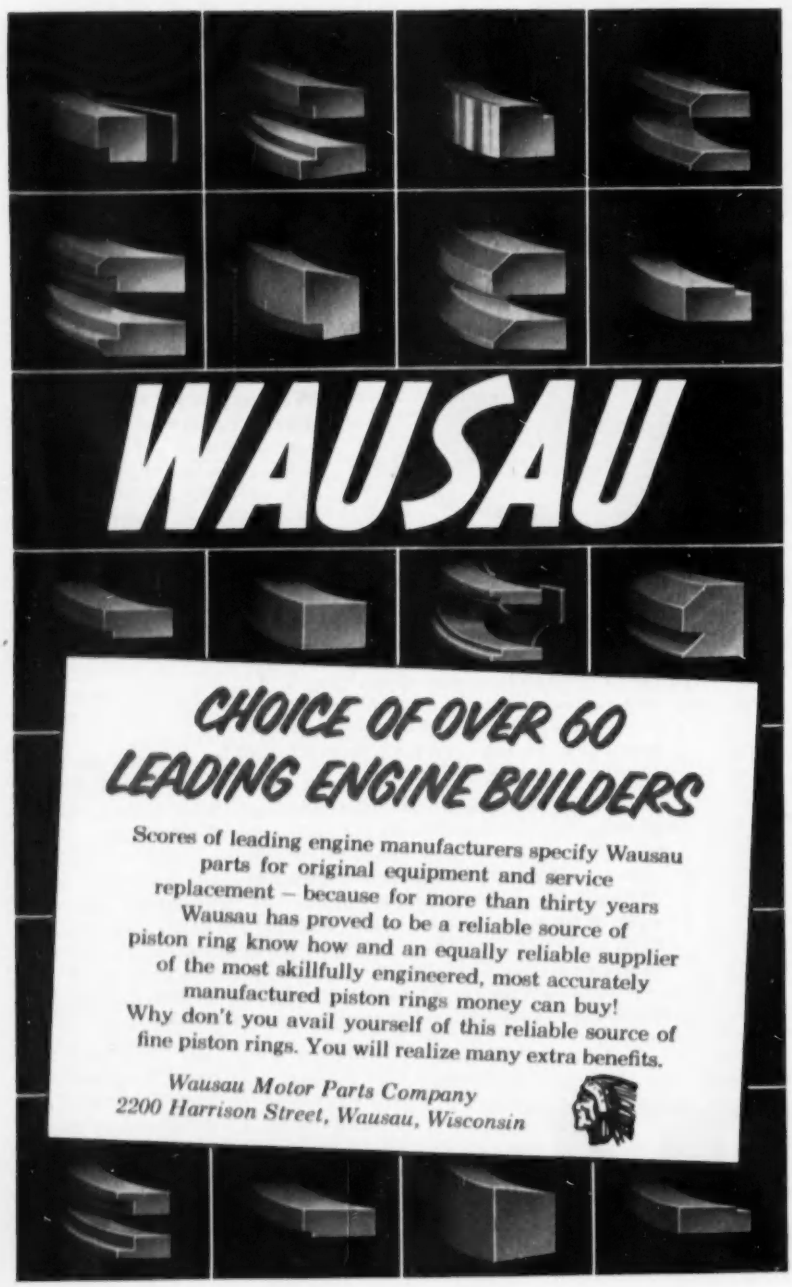
President, A. L. Riker; First Vice-President, Henry Ford, Ford Motor Co., Detroit; Second Vice-President, John Wilkinson, H. H. Franklin Mfg. Co., Syracuse, N. Y.; Secretary-Treasurer, E. T. Birdsall; SAE Council, the officers and Messrs. Swetland, Whiting, Maxim, and Alden, plus L. T. Gibbs, consulting engineer of Hempstead, L. I., N. Y., and H. Vanderbeek, Vanderbeek Tool Works, Hartford, Conn.

The founders were insistent that Members should be exclusively "professional motor vehicle engineers, designers, and constructors." Shortly, Associate memberships were made available "to suitable persons in any way connected with the design or production of motor vehicles or motor vehicle parts." Then Junior memberships were offered to "any suitable person interested in the development of the new vehicle."

Initiation fees were fixed at $15 for Members, $10 for Associates, and $5 for Juniors. Annual dues were set at $10 for all grades of membership. As currently, all prospective members were required to submit detailed and substantiated information on educational background and professional experience, and to obtain references from several members by whom they were known personally. Also as currently, all applications for membership were acted upon individually by the Society's governing body—the Council. It officially assigned each accepted applicant to "that grade in the Society to which, in its opinion, his qualifications entitle him."

During the founding years of 1905–1906 the number of members increased to something over 50. They comprised for the most part leading engineering executives, selected with care on the basis of their contribution to the development of the automobile. Membership No. 1 went to A. L. Riker; No. 2, to Henry Ford; and No. 3, to John Wilkinson, who designed the multicylinder aircooled engine which later powered the Franklin. No. 9 went to H. W. Alden, who had built a one-cylinder car in 1895 and, in the winter of 1900–1901, made the first 500-mile nonstop run.

Other early members were similarly men who had contributed substantially to the founding and development of the then infant industry. Henri G. Chatain, No. 31, had made an exhaustive study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of European automobiles in 1897, returned to build a steam-propelled vehicle of his own design, and then turned his attention to the successful development of the motorized railcar. No. 32 was Charles T. Jeffery, producer of the Rambler; No. 36, Col. W. Guy Wall, who developed the National car. President Riker had built an electric tricycle in 1898 and Howard Coffin, later to be SAE President, a steam car in 1899.

That so few of the car names then prominent have survived the years is testimony to the struggle that ensued. Of the 100-odd names affixed to passenger cars in 1905, there survive only Autocar, Buick, Cadillac, Ford, Oldsmobile, Packard, Reo, Studebaker, and White. The Ford name had yet to become a byword; General Motors had not even been conceived. Chrysler was the name of an obscure railroad man.

The first Annual Meeting of the Society was held at the New Grand Hotel in New York, on Jan. 15, 1906. The program, which set a basic pattern for all future annual meetings, gave members the opportunity to hear and discuss papers pertinent to engineering problems of the day, to transact official business, and then to attend a dinner where, with business cast aside, members could develop personal and friendly relationships despite commercial rivalry. This first business session resulted in the re-election of A. L. Riker as President.

The papers delivered at that meeting included "Materials for Motor Cars," by Thomas J. Fay, consulting engineer of Brooklyn, N. Y.; "Ball Bearings," by Henry Hess of Hess-Bright Mfg. Co., Philadelphia; and "Some Requirements for Carburetor Design," by E. T. Birdsall. The titles reflect engineering problems of the day and their inclusiveness reveals the status of engineering, but they are inadequate to convey the full flavor of those yeasty times when both Society and the industry were in ferment. In 1905, and for many years to come, the diversity of basic mechanical details was far greater than anything seen today. Witness the Gas-au-lec car of that year, which, as the name implies, used gasoline as the prime mover and electricity for the final drive; the Adams-Farwell of 1906, whose five cylinders revolved in a horizontal plane; the 3-cyl, 2-stroke Elmore of 1907, which advertised, "will run on gasoline and, after warming up—on alcohol, kerosene, whiskey, and a mixture of all;" and the Cartercar, which employed a friction drive in place of the more orthodox gearbox.

Steamers and electrics were still in the running, not to pass from the scene for many years. Steam always had its proponents, or "bugs," even among engineers, and interest in it was revived periodically. There was a flurry around 1915, occasioned by the Doble, and again in the Twenties when a half-dozen teamers reached the market. The *Saturday Evening Post* of Sept. 11, 1920, ran a long article urging steam propulsion as a solution to the then threatening

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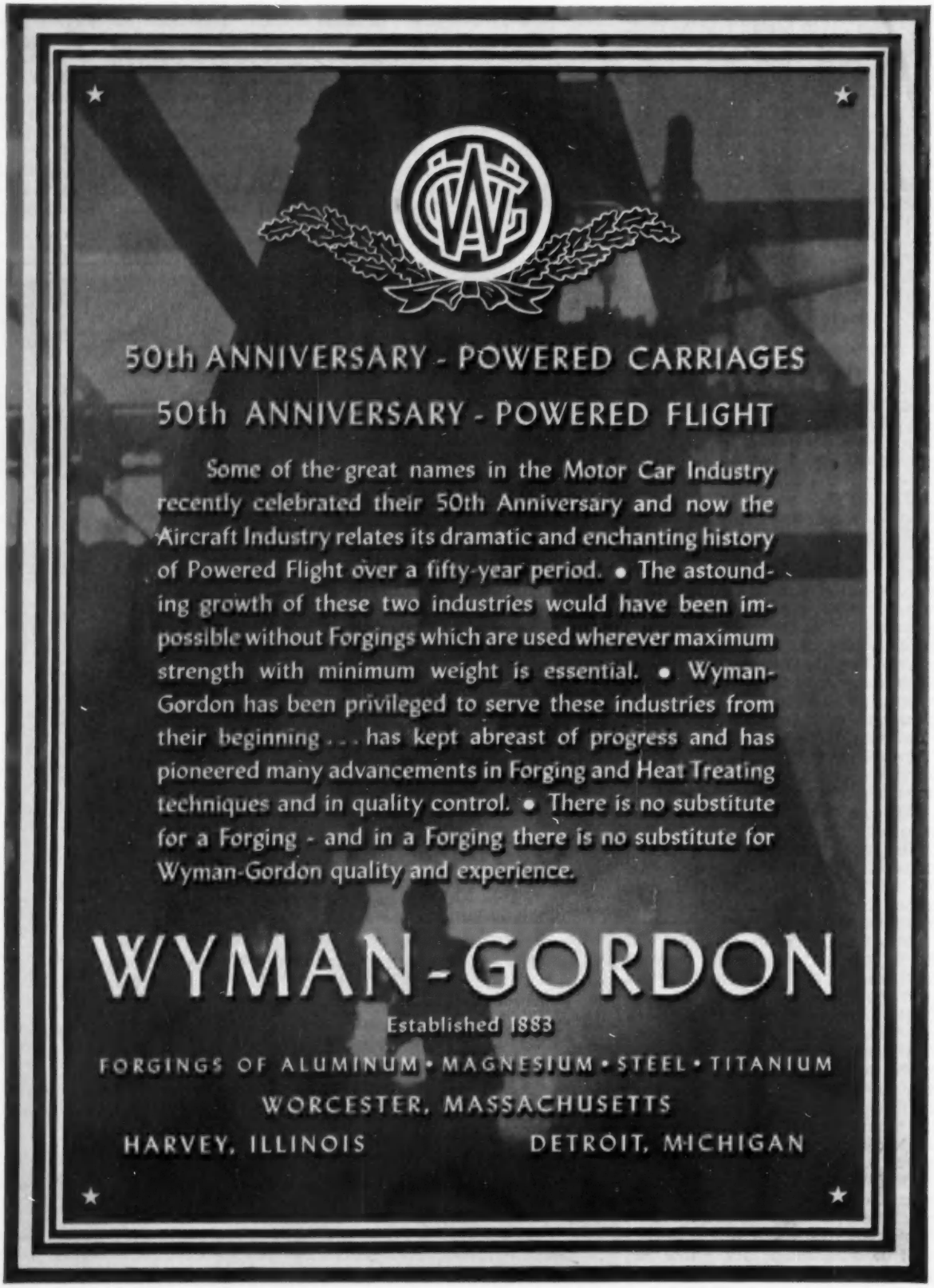
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fuel shortage, even mentioning that a paper describing a remarkable steam car had been presented at a meeting of the SAE.

So it can be said of the infant industry that it was not sure where it was going, but knew it was on its way. Accordingly, manufacturers were willing to try anything once, and, in their groping, they appear to have tried practically everything. This attitude is ably reflected in William C. Durant's explanation for acquiring the Elmore and Cartercar in 1908, for his newly formed General Motors. It was, he said, because no trends were visible and he wished to be ready for any eventuality. Small wonder that engineers had plenty to discuss at the early Society meetings, for what the industry needed was the direction that engineering alone could give it.

From the outset, then, both the automobile industry and the Society grew apace. If you wish to say that the development of the automobile created the SAE, no one can deny it. If you prefer to think that the Society molded the industry, that, too, cannot be denied. Each view affords a reflection of the other organization. The important thing is that from now on there was uninterrupted growth.

CHAPTER II

Growing Pains

TWO major factors have influenced the Society's growth. We might term the first external pressures—technical and economic. Then there are the internal pressures, which arise from acceptance of the external.

Technical and economic developments point up a need. The need comes to be recognized, and steps are taken to handle it. A committee is formed, which results in expansion of activity. Stated in still another way, the function of SAE begins in generalities and quickly moves on to the specific, with the two forces always at work. The centripetal draws together diverse, allied activities under the Society's wing, while the cultivation of an activity, which multiplies and spreads the work, is centrifugal or dispersing. Having the two forces always in operation makes for tension and growth, and for chronic growing pains.

All this is obvious today, with the perspective afforded by 50 years, but it is unlikely that the

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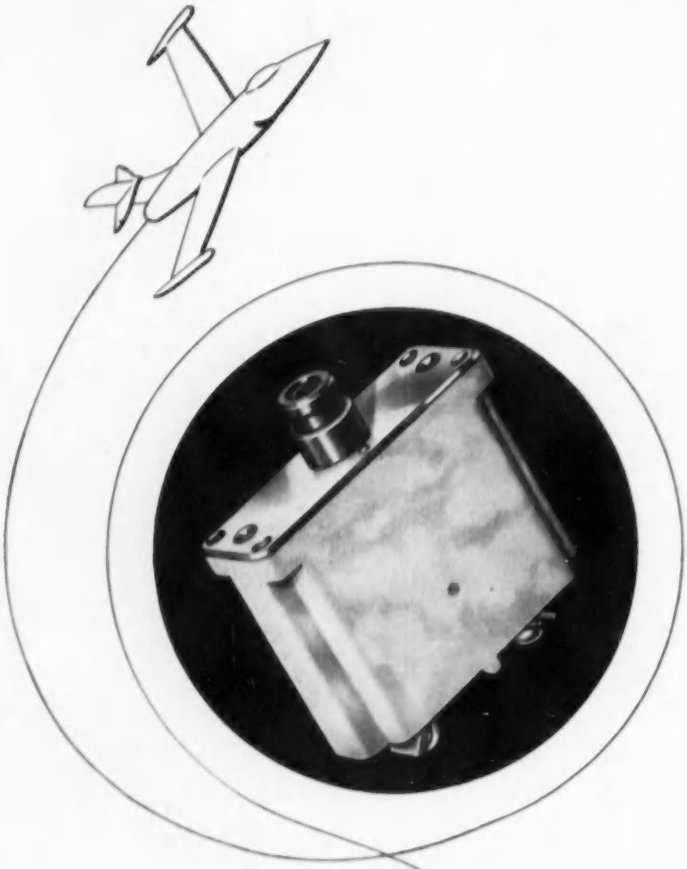

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founders could feel the growth for the pains. Spare-time Secretary Birdsall, for instance, was having trouble keeping records current and maintaining contacts with peripatetic members. Then, to aggravate his difficulties, a membership campaign launched under the direction of C. B. Hayward, editor of *The Automobile*, doubled the roster. So we find, at the 1908 Annual Meeting, the decision being reached to obtain the services of a regular secretary. The office was to remain on a part-time basis, however, and Alexander Churchward of General Electric was appointed to it. Then, in 1909 the SAE was incorporated under the laws of the State of New York.

By 1910, membership had again doubled, bringing with it another bout with pain. In the opinion of Howard E. Coffin of the Hudson Motor Car Co., who had assumed the presidency, the Society's affairs were drifting into a disastrous confusion which could be stemmed only by having a paid, full-time staff officer. Coffin promptly employed Coker F. Clarkson, formerly secretary of the Mechanical Branch, ALAM, as "SAE General Manager."

Clarkson's first task was to survey SAE activities. That survey confirmed Coffin's impressions. In a special report to the Council he painted a dismal picture of jumbled records, disorganized activities, inadequate financing, and dissatisfied membership. Coffin proposed that if the Society were to serve automobile engineers properly, establish automobile engineering as a recognized profession, and function without suffering the disruptive effects of competitive commercialism, new policies and new methods were mandatory.

A stormy Council raised questions of constitutionality, financial procedure, policy, and even of impeaching the president. It was protested that neither constitution nor bylaws provided for a general manager. Coffin retorted that SAE now had one. Members complained that the Council had not been consulted. Coffin explained that they might regard the new general manager as working directly under the president. When it was asserted that finances warranted no commitment for expenses obviously greater than income, Coffin announced that he, personally, would guarantee the general manager's salary and give him a new automobile annually to boot. Under the direction of a

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general manager, said Coffin, the Society would grow in membership, achievements, and revenue. He insisted that orderly operation would assure membership growth and thus meet the increased expense.

Convinced of the Society's potentialities by Coffin's confidence, the Council acted to establish the general manager's position and office, but would not permit any single officer to have the responsibility for financing. It offered SAE promissory notes as security for a $4000 loan made jointly by President Coffin and Messrs. Swetland, Riker, and Hess. Five years later, the loan was repaid in full with interest, accompanied by a resolution of thanks.

Within a short time dues were being collected even from delinquent members, while membership activities and finances were increasing steadily. On taking over the office, General Manager Clarkson dedicated his full time, his many talents, and his great heart to piloting the SAE, guiding its progress successfully for 20 years. Upon his death in 1930, he was succeeded by John A. C. Warner, who had served SAE from 1923 to 1926 as manager of the Research, Meetings, and Sections Departments.

In retrospect, the year 1910 takes on great significance in the life story of SAE. In addition to being the year in which the operations of the Society were placed on a sounder footing, there was also the beginning of standards work and the organizing of Sections. In a later chapter will be told how the standards work grew and gave rise to the need for research, and, finally, for a Technical Board. And how the Sections prospered and multiplied in number to be followed by the formation of SAE Groups and Student Branches.

The following year (1911) was also important. At the Annual Meeting an effort was made to admit to full membership "persons of prominence" in the industry. It was soundly defeated, thus reestablishing the principle of restricting full membership to competent practicing engineers of high repute.

An effort was also made to broaden the privileges of Associate members. This, too, was defeated, on the grounds that Associate memberships were created to accommodate non-engineering representatives of manufacturers, including some company heads and sales managers. The standing

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and reputation of an engineer was held to take precedence over his standing on the payroll of any company, as far as SAE was concerned.

In that same year, in April, the *SAE Bulletin* published in its first issue a formal listing of "Positions Available" and "Men Available." Thus early, members began to help each other to win gainful employment. Since May, 1922, however, this function has been handled under the direction of a separate service, the SAE Placement Committee.

CHAPTER III

Broadening Interests

IN adaptation to centrifugal and centripetal forces, the structure of the Society changed. And the result was a strengthening of SAE unity. To understand how this was achieved, it is necessary to switch back to 1905 to examine the initial organizational structure, then trace the changes as they transpired.

The Council, the governing body of the Society, had 10 members, comprising the president, two vice-presidents, six managers and the secretary-treasurer. Between 1905 and 1910, first one and then two past-presidents were included, and the secretary, whose office had become distinct from that of treasurer, was dropped. In 1914, the six managers were designated Councilors. No further organizational changes of any great importance took place until 1916. In that year the American Society of Aeronautic Engineers and the Society of Tractor Engineers effected a merger with the SAE, while the National Association of Engine and Boat Manufacturers and National Gas Engine Association turned over their engineering and standards work to the Society. As a consequence, the plan of organization was changed to include five second vice-presidents representing motor car, tractor, aviation, marine, and stationary internal-combustion engineering, respectively. Here we find the first indication of a major adjustment to changing times; an acknowledgment of specialized growth within the industry itself.

Inclusion of allied interests greatly increased the importance of the Society by expanding the scope of its work. Also, it made many Members feel that the word "automobile" in the Society's title was no longer adequately expressive, although the founders must

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have anticipated such doubt and thought they had prepared for it, as witness this statement made before a meeting of the Society by its first president, A. L. Riker:

"The Society had to make a definition of the meaning of the word 'automobile,' which could not be found in the dictionary. It was finally decided that the word covered any self-propelled vehicle running on the land, in or under the water, or in the air."

Nevertheless, at the Summer Meeting, 1916, someone suggested the word "automotive" as being more descriptive of the Society's interests, and by mail vote of the members, the SAE became the Society of Automotive Engineers, Inc., as of Feb. 28, 1917.

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Thus, changes there were of minor and major nature in response to developing need, but none of greater importance than that taking place in 1929, when the first vice-presidency and the five second vice-presidencies were abolished and replaced by eight vice-presidencies representing specific Professional Activities of the Society designated as Aircraft, Aircraft-Engine, Diesel-Engine, Motor-Truck and Motorcoach, Passenger-Car, Passenger-Car Body, Production, and Transportation and Maintenance Engineering. Later, as new needs demanded, four more vice-presidencies were added, representing the Air Transport, Engineering Materials, Fuels and Lubricants, and Tractor and Farm Machinery Activities.

On the face of it, this change would seem little more than a substitution of terms. Actually, it was much more than that. Members had agitated for a more positive representation of these activities on the Council and claimed that there existed these special spheres of interest within the interests of the Society as a whole. The Society accepted the truth of this claim and adjusted to it. It gave recognition to the value of intensified interest in the specific and set about organizing to insure that greater autonomy gave the necessary stimulation without impairment of organization solidarity of the naturally related interests.

Each of these Professional Activities had its genesis far back in the history of the Society. The majority even went back to founding days, and when the proud history of each is told, the scope of SAE work and achievement stands, in the main, revealed.

First official notice of aeronautics, for example, appeared in the 1911 "SAE Transactions." In that year some members urged the launching of an aeronautical branch, while others thought it more to the point to prohibit by law the operation of the flimsy contraptions then called airplanes.

A year before the aeronautical engineers merged with the SAE, a paper on "Aeronautical Engines" was presented at the 1915 Summer Meeting. The following year, three papers were presented. And thereafter few Annual or Semi-Annual Meetings lacked a discus-

Result of diversification:

Lockheed increases engineering staff

Diversification at Lockheed is resulting in more and better careers for engineers.

New career positions have been created by such diverse projects as radar search planes, turbo-prop and turbo-compound transports, jet transports, vertical rising aircraft, extremely high speed jet fighters, trainers, patrol bombers and a number of significant classified activities.

To the career-conscious engineer, this diversified development and production program means: 1) more job security and 2) more opportunity for promotion with so many projects in motion.

Positions open include:

DESIGN ENGINEERS

at all levels for creative design in structures, hydraulics, mechanical and electrical fields.

Requirements: An engineering degree or equivalent experience; some aircraft experience preferred.

STRESS and STRUCTURES ENGINEERS

at all levels to perform analysis of structural and mechanical components which determine design criteria.

Requirements: An engineering degree and experience in aircraft structures or related fields.

WEIGHT ENGINEERS

to perform weight analysis and projections during preliminary design, production design and flight test.

Requirements: A degree in engineering, mathematics or physics with experience in weight control and estimations.

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Aircraft experience is not necessary to join Lockheed. An engineering degree or equivalent experience qualifies you to receive transitional or on-the-job training—at full pay.

Lockheed offers you increased salary rates now in effect; generous travel and moving allowances; an opportunity to enjoy Southern California life; and an extremely wide range of employee benefits which add approximately 14% to each engineer's salary in the form of insurance, retirement pension, sick leave with pay, etc.

Those interested are invited to write E. W. Des Lauriers for an application blank and illustrated brochure describing life and work at Lockheed. Coupon below is for your convenience.

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have anticipated such doubt and thought they had prepared for it, as witness this statement made before a meeting of the Society by its first president, A. L. Riker:

"The Society had to make a definition of the meaning of the word 'automobile,' which could not be found in the dictionary. It was finally decided that the word covered any self-propelled vehicle running on the land, in or under the water, or in the air."

Nevertheless, at the Summer Meeting, 1916, someone suggested the word "automotive" as being more descriptive of the Society's interests, and by mail vote of the members, the SAE became the Society of Automotive Engineers, Inc., as of Feb. 28, 1917.

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Thus, changes there were of minor and major nature in response to developing need, but none of greater importance than that taking place in 1929, when the first vice-presidency and the five second vice-presidencies were abolished and replaced by eight vice-presidencies representing specific Professional Activities of the Society designated as Aircraft, Aircraft-Engine, Diesel-Engine, Motor-Truck and Motorcoach, Passenger-Car, Passenger-Car Body, Production, and Transportation and Maintenance Engineering. Later, as new needs demanded, four more vice-presidencies were added, representing the Air Transport, Engineering Materials, Fuels and Lubricants, and Tractor and Farm Machinery Activities.

On the face of it, this change would seem little more than a substitution of terms. Actually, it was much more than that. Members had agitated for a more positive representation of these activities on the Council and claimed that there existed these special spheres of interest within the interests of the Society as a whole. The Society accepted the truth of this claim and adjusted to it. It gave recognition to the value of intensified interest in the specific and set about organizing to insure that greater autonomy gave the necessary stimulation without impairment of organization solidarity of the naturally related interests.

Each of these Professional Activities had its genesis far back in the history of the Society. The majority even went back to founding days, and when the proud history of each is told, the scope of SAE work and achievement stands, in the main, revealed.

First official notice of aeronautics, for example, appeared in the 1911 "SAE Transactions." In that year some members urged the launching of an aeronautical branch, while others thought it more to the point to prohibit by law the operation of the flimsy contraptions then called airplanes.

A year before the aeronautical engineers merged with the SAE, a paper on "Aeronautical Engines" was presented at the 1915 Summer Meeting. The following year, three papers were presented. And thereafter few Annual or Semi-Annual Meetings lacked a discus-

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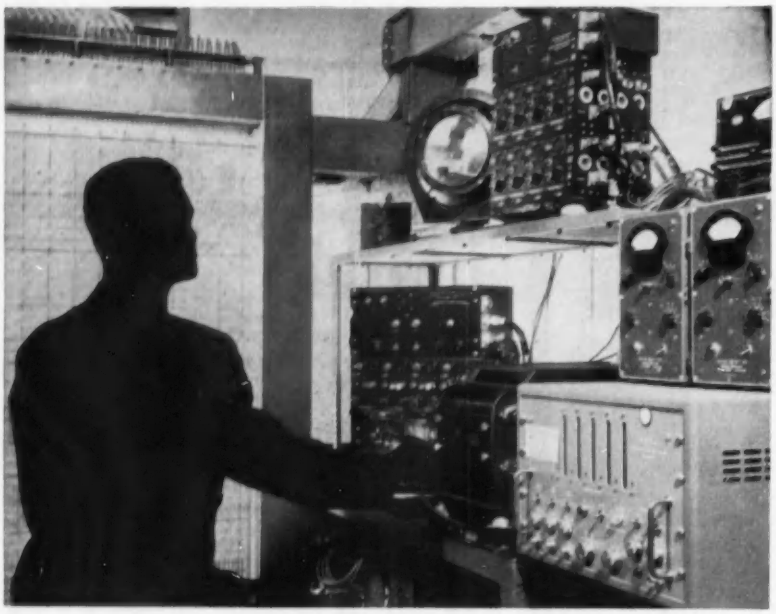

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sion of aeronautic work. Following the aforesaid merger, an Aircraft-Engine Division was formed under the General Standards Committee, and the next year came an Aircraft Division.

The first aeronautic meeting was held at New York in 1917. Four Sections—Detroit, Metropolitan, Chicago, and Southern California—organized local aeronautic activities. Finally, when the Society was reorganized on a Professional Activity basis in 1929, the Council gave formal recognition to Aircraft and Aircraft Engines as Professional Activities. The Aircraft-Engine Activity became the Aircraft-Powerplant Activity in 1945 in recognition of turbine and jet powerplant developments.

Diesel engines had to sell themselves to SAE Members and to develop engineering interest the hard way. First reference to them appears in the Society records of 1909, and it was far from complimentary. In the opinion of the members, the diesel offered little or nothing as a vehicle powerplant, but it was worth watching because of its high thermal efficiency. Obviously, some eyes were focused on it, for in 1916 we find the Council considering the advisability of gathering and disseminating diesel-engine technical data. The stated purpose was engineering improvement of this powerplant since it might become the universal power producer.

Threat of a gasoline shortage in 1917 and 1918 caused more attention to be paid to the diesel and it became the subject of numerous technical papers. In 1929 a Diesel-Engine Activity was set up and in 1930 the SAE General Standards Committee formed a Diesel-Engine Division.

Early records show considerable attention being given to both trucks and motorcoaches. At meetings of both Society and Sections, not only individual papers but entire sessions were devoted to these topics, and at no time was the Standards Committee idle with respect to commercial vehicles. In a paper, "The Economics of Weight Reduction," presented in 1909, the author makes it plain that he directs his remarks to commercial vehicles quite as much as to the passenger car, or pleasure car, as he called it.

From the outset there was semantic trouble. Should the truck be called a freight wagon, an industrial vehicle, or a motor truck; was a bus a motorbus or

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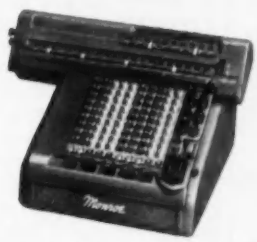

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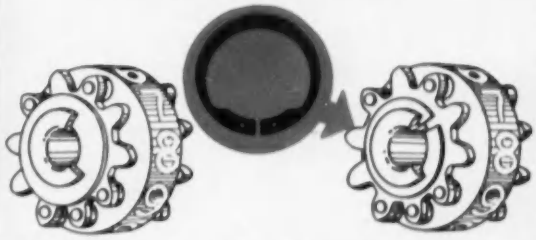

Old Way. One-piece assembly was spun together. Spinning operation was costly, resulted in high scrap loss.

Truarc Way. Two-piece assembly is held together by one Truarc Ring (series 5100). Rejects: practically zero.

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Old Way. Collector Disc assembly was formerly riveted, requiring skilled labor. Riveted Collector Disc could not be removed in the field.

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Old Way. Washer riveted on end of assembly for zoning control. Costly, troublesome, hard to obtain critical zoning required.

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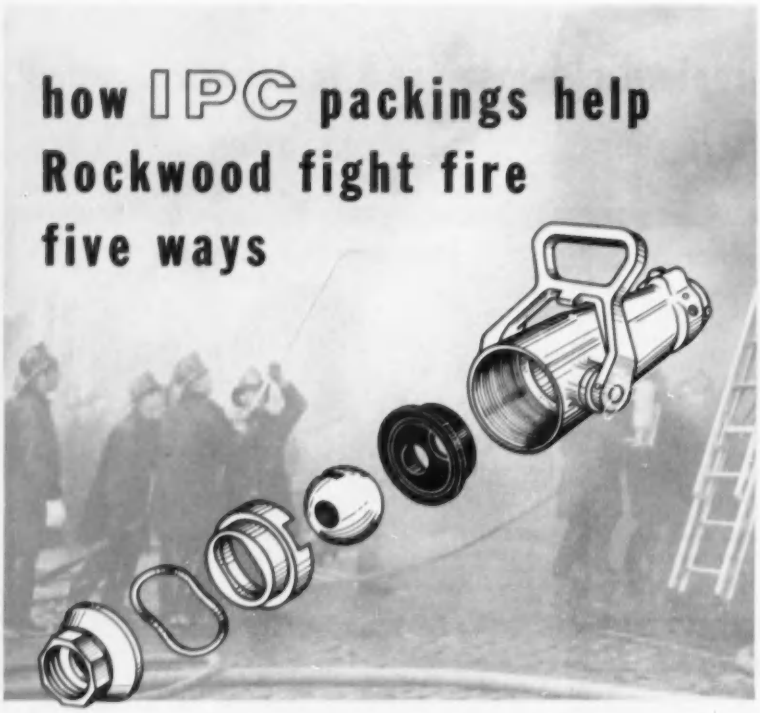
how IPC packings help Rockwood fight fire five ways



In Rockwood Sprinkler's all-purpose nozzle, fire-fighters have a basic weapon for fighting fire with five different types of water action. From high-velocity water fog to solid foam streams, the floating ball in the nozzle body can be positioned to the desired action.

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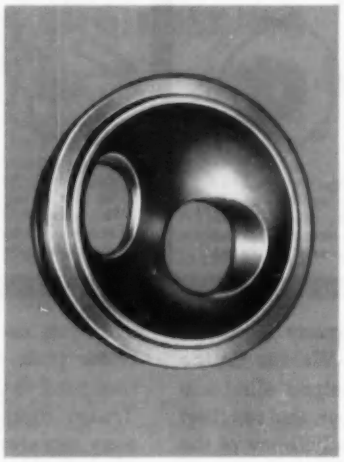

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P1

motorcoach? When the reorganization of 1929 took place and commercial vehicles became recognized as a Professional Activity, it was "Motor Truck and Motorcoach." Five years later this became the "Truck, Bus, and Railcar Activity" and in another seven years, the "Truck and Bus Activity," the promise of the railcar having petered out.

Since passenger-car design and construction prompted the founding of the SAE, passenger-car activities had top billing from the very first day. It is no exaggeration to say that every feature of the present-day car has been a subject for debate at some time in the past. But here, again there was trouble over names. Early records referred to passenger cars as motor cars, automobiles, road locomotives, machines, and pleasure cars. The adjective "pleasure" automatically classed the automobile as a luxury, and tax authorities were quick to take advantage of it. So the term "passenger car" evolved, and with the industry's active backing, it came, in time, into general usage. In view of the uninterrupted and undiminishing interest of members in every phase of the passenger car, inclusion of passenger cars in the 1929 reorganization was a logical development.

For some years following the founding of the Society, car bodies were taken more or less for granted. As someone has said: "The early problem was to get the car to run; later, it became a problem to get it to stop." First mention of the body as being a topic worthy of discussion seems to have been in a paper delivered in 1908 on "Usually Unobserved Refinements of Automobile Construction." The first paper devoted exclusively to body design did not appear until 1914. But in it the author talked on "Tendencies in Body Design," saying among other things:

"There is undoubtedly a great demand for closed cars . . . Present tendencies in body design are toward the streamline type . . . The owner of the future will demand a car that will be comfortable to ride in at all seasons, that can be changed from open to closed with a minimum of time and trouble, and in which all accessories and spare parts will be covered and protected and easily kept clean. Bodies will look odd to us as we experience the evolution; first, the concealment of the extra tire, then perhaps the elimi-

nation of the usual folded top, then nonprojecting lamps, etc. Finally we will wonder why formerly we covered a car with so many trappings."

That was a truly prophetic utterance, for prior to 1914 cars were predominantly open because far less expensive than the closed, and the so-called "one-man" top required two men to manipulate it. It was not until engineers made the low-priced closed car a reality, and that was just beginning around 1914, that the automobile came to be a practical year-around vehicle for mass transportation.

Problems of production have been uppermost from the very early days of the industry and the Society's appreciation of their importance is testified to in published records. In 1910, a paper presented under the title, "Cork Inserts as Applied to Machinery Used in the Manufacture of Motor Vehicles," was addressed primarily to "such engineers, mechanical superintendents, and others as are directly connected with the daily output of motor cars and the economical operation of the factory."

In his presidential address the following year, Henry Souther made this statement: "There are many of our members having good knowledge of shop management, of costs and labor-saving devices. If they will write upon these subjects, the whole industry will be benefited. Such information is just as valuable in its way as the more theoretical information of the electrician and the motor engineer."

Production papers were presented subsequently at Society and Section meetings, and a general meeting devoted exclusively to production topics took place in 1922. In 1923, Past-President B. B. Bachman urged that effort be made to bring the design and production engineers into closer relationship. More direct representation on the Council was first urged in 1925, and in that same year a Production Division was organized by the General Standards Committee.

Recognition of production as a Professional Activity came with the reorganization in 1929. All during World War II and thereafter, the mounting interest in production was apparent and reflected in both meetings and membership growth. In 1953 the first "Special Production Issue" of the *SAE Journal* was published. Production membership began to grow faster than almost any other

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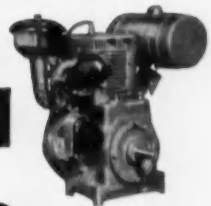

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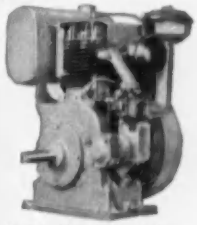

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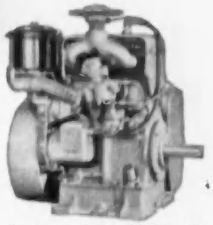

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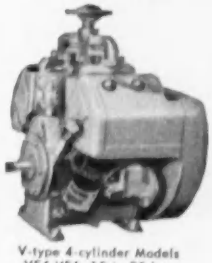

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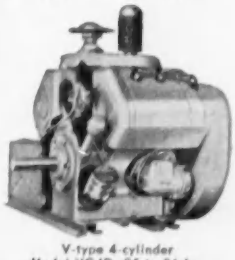

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SAE Activity. By 1955, production interest had reached new peaks.

"Motor Trucks for Railroad Service," a paper discussing store-door delivery and less-than-carload lots, carries the published record of SAE interest in transportation and maintenance back to the year 1910. Two years later, a paper, "Cost of Work with Gasoline Motor Trucks," delved into operating expenses. With the growth of interest in this subject, we find Charles M. Manly including this statement in his presidential address of 1919:

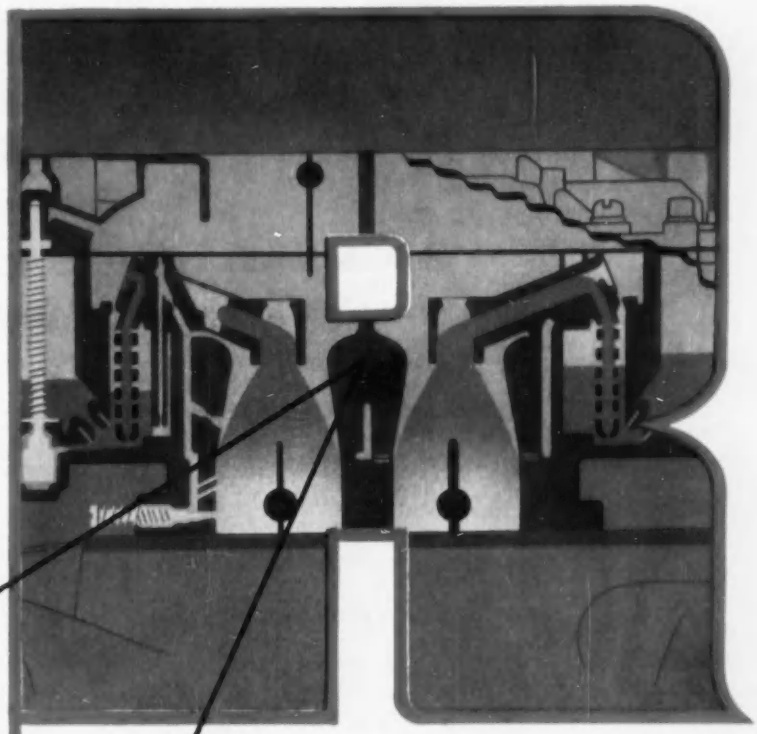
"The work of the automotive engineer is not finished, but merely begun, when the machines are designed and built . . . There is more need today for real engineering work in connection with planning and organization of the operating end of automotive vehicles and machines than there is in connection with the design and construction of them." Two years later, President-Elect David Beecroft, noting that world registration of automobiles had reached 9,000,000, said at the Annual Meeting: "It is just as essential that they be kept at a standard of efficient operation and scientific application as it is that we go on building more."

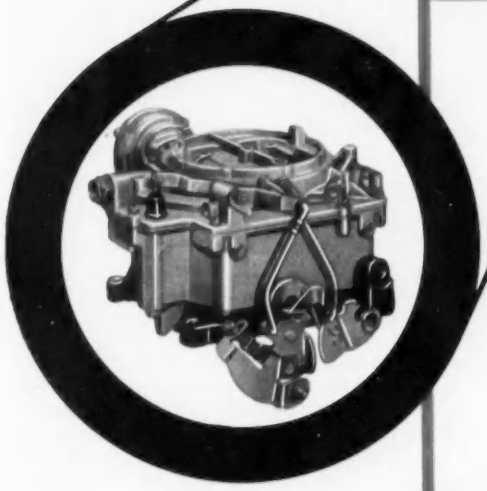
The first national meeting devoted to operation and maintenance occurred in 1921, while automotive transportation meetings were held in 1923 and 1924. Repeated attempts were made between the years 1923 and 1926 to have official recognition given to engineers who managed and operated commercial vehicle fleets, and the idea was hotly discussed until the reorganization in 1929 included Transportation and Maintenance as an Activity.

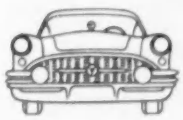
The fact that the Fuels and Lubricants Activity was not formed until 1933 does not signify any lack of interest in the subject. To the contrary, they received a tremendous amount of attention from the very earliest days. Threat of a fuel shortage in 1907 occasioned a great deal of concern and even prompted a paper on "Alcohol as a Fuel for the Automobile Motor." And around the same year one engineer observed, "An impression that ball bearings will operate without lubricant is more general than one might think," indicating that lubricants were beginning to get the attention they deserved.

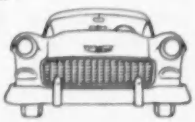
Discussion grew in volume and by 1913 the Council decided some

Engineered for the high compression era!









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Stackpole finds pride in the fact that its own beginning dates back an almost equal number of years.

Throughout this time, our aim has been twofold:

To develop and produce products that rank among the best in the many fields served; and to back these with service and attention to detail that makes doing business with Stackpole more than a casual, impersonal transaction.

These policies will, of course, be continued as the best means of meeting the challenges and problems of the next fifty years.

STACKPOLE

BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT
ELECTRICAL CONTACTS • FIXED AND VARIABLE RESISTORS
SLIDE SWITCHES • IRON CORES • FERROMAGNETIC CORES
WELDING RODS, PLATES AND PASTE • RESISTANCE WELDING AND BRAZING TIPS
VOLTAGE REGULATOR DISCS • GRAPHITE BEARINGS • CLUTCH RINGS
FRICTION SEGMENTS • SPECTROGRAPHITE • POROUS CARBON
MOLDS AND DIES • BRAZING FURNACE BOATS
ELECTRIC FURNACE HEATING ELEMENTS • GROUND RODS . . . and many more.

action must be taken. Accordingly, it appointed a fuel committee to function as a subcommittee of the Miscellaneous Division of the Standards Committee. Apparently this subcommittee did not function long or very successfully, for in the following year we find the president saying: "We did have a fuel committee, last year, . . . but it appeared to be so large a subject that the committee, with the meager facilities at hand, did not get very far."

But the subject of fuels wouldn't die. It couldn't die, it was too important. After much debate the Council decided to establish a Fuels and Lubricants Division of the Standards Committee. This was formed in 1917. only to be discontinued in April, 1919. When it was revived the next year, fuels were being taken care of elsewhere, so there resulted a Lubricants Division of the Standards Committee.

Obviously, fuels had given the Society organizational difficulties, but for reasons that are not immediately clear. If the truth be known, the feeling had been growing up that fuel problems could be solved only by cooperative effort, or, as the retiring president, C. F. Kettering, said at the 1919 Annual Meeting, by oil and engine people and everyone else working together. Ultimately such cooperative work was undertaken under the aegis of the Research Committee, formed in 1921. Cooperative Fuels Research, known familiarly as CFR, was set up jointly by the Society, American Petroleum Institute, National Automobile Chamber of Commerce, and the Bureau of Standards. And until 1933, when the Fuels and Lubricants Activity was formed, special sessions devoted to fuels and lubricants were sponsored by the Research Committee.

Tractor engineering interested many SAE members even before the merger with the Society of Tractor Engineers in 1916, and at no time was there a cessation of that interest. Among the first of the meetings held for the sole consideration of tractor engineering problems, we find one at Fremont, Neb., in 1916 and one at Kansas City, Mo., in 1917. In 1935 the Council approved the organization of a Tractor and Industrial Power Equipment Activity, which became the Tractor and Industrial Activity in 1940, and the Tractor and Farm Machinery Activity in 1943.

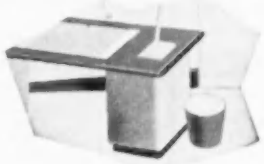
To some degree during World War I and extensively during

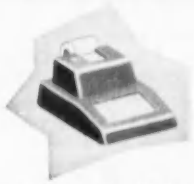
Here's Marvibond*

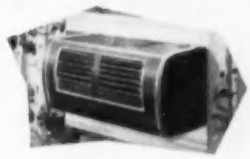
a new vinyl-to-metal laminating process that gives sheet metal products all these advantages...

- lasting protection against rust and corrosion
- practically any surface effect desired
- superior abrasion resistance
- outstanding resistance to perspiration and most chemicals
- uniform coverage of almost any thickness
- good sound-deadening properties
- less costly fabrication

vending machine housings


waste baskets


business machine housings


air conditioner cabinets

Window moldings and dashboards of Marvibonded laminates could be permanently clad with vinyl material to match door upholstery and seat trim. And practically any choice of texture is possible–from glare-free matte finishes to rich leather-like grains.

There'd be no checking or flaking, no worries about scratched paint—no need for waxing or other care. The tough, chemical-resistant vinyl cleans with a wipe.

What's more, the vinyl surface would always be warm and pleasant to the touch. Marvibonding ends problems of rust from moisture condensation. And it helps to deaden sound, as well as insulate against squeaks from metal to metal contact.

Why not Marvibonded panels and trim! Plenty of excellent reasons *why*. Excellent reasons why for hundreds of similar applications—like radio and television housings, business machine covers, vending machines, air conditioners, waste baskets, and many many more.

Better see what Marvibond can mean to your product! Write the address below today.

*Pat. applied for

Naugatuck Chemical

Division of United States Rubber Company
Naugatuck, Connecticut

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario
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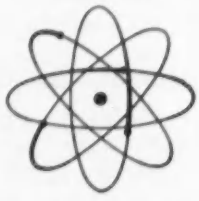
Engineers! Scientists!

UNLIMITED OPPORTUNITIES IN

Atomic Power

AT

Westinghouse



In a new plant on the outskirts of Pittsburgh, Pa., atomic energy will be explored as a source of power for transportation and industry.

Opportunities in this new field are unlimited for:

MECHANICAL ENGINEERS

Fluid flow, heat balance, valves, mechanical and hydraulic devices and mechanisms, design and application of high pressure piping and systems, heat transfer, rotating machinery, general steam apparatus and steam power systems.

ELECTRICAL AND CONTROL ENGINEERS

Development, design and application of control systems and apparatus for nuclear plants. This includes servo analysis, application of analog computers, functional and operational analysis of mechanical and electrical power systems and the application of temperature, pressure, flow instruments, nuclear instruments, motor controllers, regulators, control panels and special electrical controls.

PHYSICISTS

Basic reactor physics, reactor design and analysis, control systems, and experimental testing.

METALLURGISTS

To conduct basic research in physical metallurgy, corrosion and radiation effects on metals; applied research and development on materials and processes for reactor components in the field of vacuum induction melting, ceramics, powder metallurgy, welding, metal working and non-destructive inspection.

Openings also exist for Chemical Engineers, Chemists and Radio Chemists.

SALARIES

Open. Ample housing available. Benefits include a hospitalization-insurance program, and graduate study under the Westinghouse program at company expense.

HOW TO APPLY

United States Citizenship is required!

Send resume concerning your experience and education to:

Mr. C. F. Stewart, Atomic Power Division,
Westinghouse Electric Corporation
P.O. Box 1468, Pittsburgh 30, Pa.

World War II, the Society expanded and extended its aeronautical engineering activities and interests. In so doing, it dug even deeper into the engineering aspects of airplane and airline operation. Engineering comprehension of the operating end became increasingly vital to design, construction, and standardization, and so we find the programs of meetings devoted more and more to technical treatises on air cargo, air transport, and air terminal operations.

The Aircraft and Aircraft Powerplant Activities sponsored numerous meetings throughout 1940, 1941, and 1942. The General Standards Committee's Aircraft and Aircraft Powerplant Divisions developed aeronautical parts and materials standards. When the 1944 Annual Meeting rolled around, speakers expounded the importance of dominating the air in both war and peace and predicted a tremendous postwar growth in air transport. The following year, the Council recognized Air Transport as a Professional Activity.

The first technical paper presented at the first formal SAE meeting, January, 1906, was entitled "Materials for Motor Cars." Materials have come a long way since that day and so has engineering knowledge of them. Progress has been fostered by the Society's work on materials standardization as well as by participation in the wartime development and use of the so-called "National Emergency" steels. Indeed, the need for conserving materials in critically short supply and for finding adequate substitutes served the excellent purpose of directing attention to the essential nature of materials and the need for furthering materials engineering. So once again, we find an interest becoming highly specialized within the framework of automotive engineering, and recognition being given to its professional status with the formation by the Council of an Engineering Materials Activity in 1947.

With the background of these Professional Activities freshly in mind, it must be fairly obvious that the establishment of a Professional Activity is an organizational matter and not the adding of something new to the work of the Society. There were vice-presidents representing specialized interests on the Council in 1916 with the organizational plan put into effect that year. There was

perfecting a basic process to serve you better

A few of the many parts and products we make:

AUSCO Saf-Lift Bumper Jack and Hi-Range or Standard Hydraulic Axle Jacks: "Mates" of the millions of original equipment jacks supplied to car, truck and tractor builders.

AUSCO Cast Alloy Steel Crankshafts: For motor car, truck and tractor engines.

AUSCO Automotive Castings: Malleable and pearlitic malleable iron and steel castings for large and small automotive parts.

AUSCO PTO Clutch: For easier operation of farm machines.

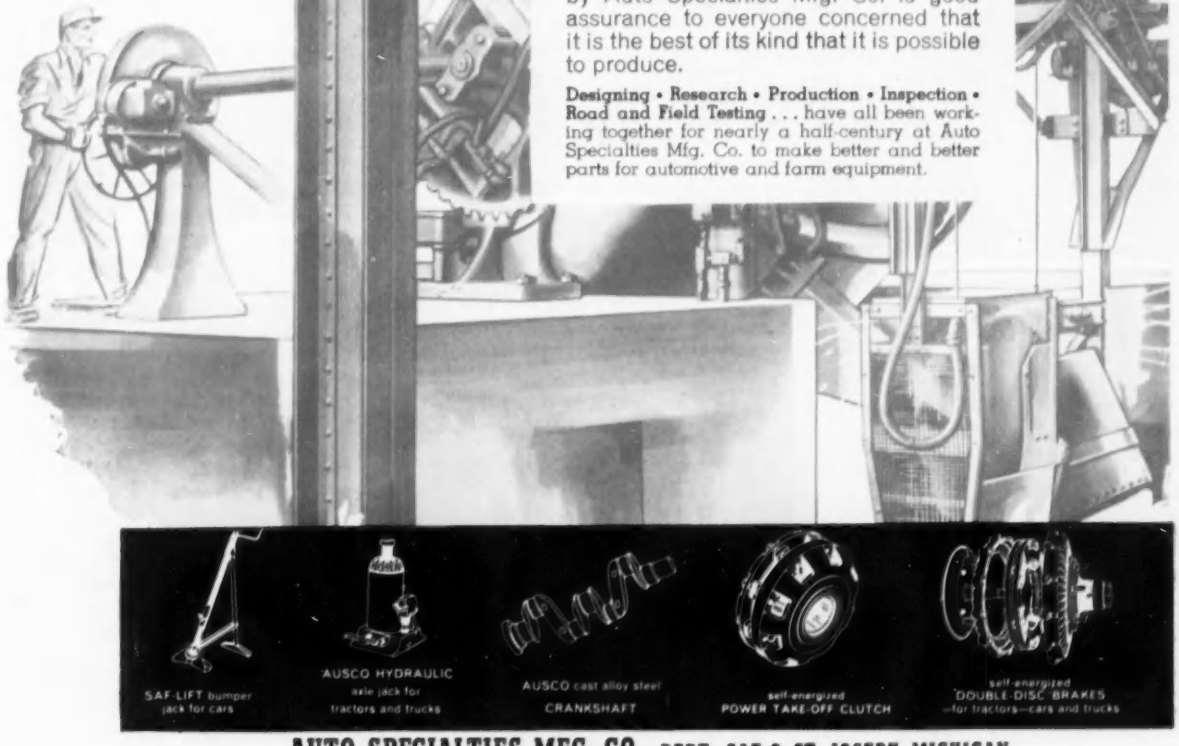
AUSCO Double-Disc Brakes: Standard equipment on more than 60 large-production models of 18 makes of tractors, and now ready for cars and trucks.

Producing superior malleable castings of large and small parts for manufacturers of automotive and farm equipment has been one of the principal operations of the Auto Specialties Mfg. Co., a leading specialist parts manufacturer for nearly half a century.

Auto Specialties Mfg. Co., is ideally suited to produce superior castings . . . by location, central to the great Midwest manufacturers and convenient to an abundant supply of sand and power . . . by our pioneering practices now widely accepted by the industry . . . by our unique method of duplexing with cupolas and electric furnaces . . . and by never-ending improvement at each step —metallurgical control, melting, molding, core-making, pouring, annealing, and inspection.

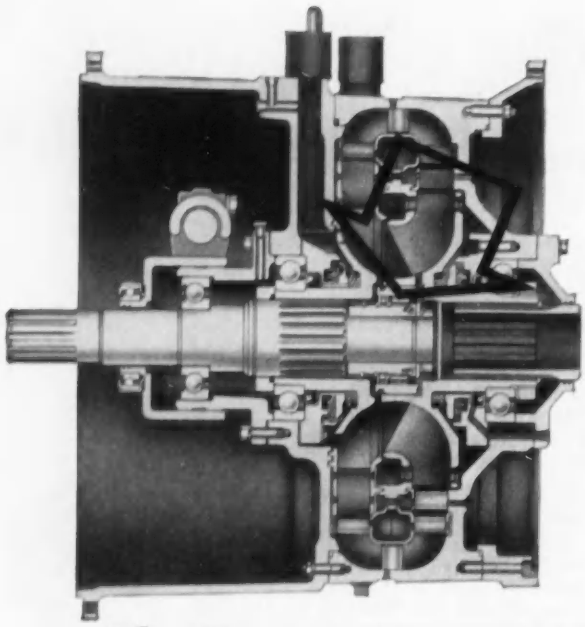
Whether it is an entire product or only one of its parts, the fact that it's made by Auto Specialties Mfg. Co. is good assurance to everyone concerned that it is the best of its kind that it is possible to produce.

Designing • Research • Production • Inspection • Road and Field Testing . . . have all been working together for nearly a half-century at Auto Specialties Mfg. Co. to make better and better parts for automotive and farm equipment.


SAF-LIFT bumper jack for cars
AUSCO HYDRAULIC axle jack for tractors and trucks
AUSCO cast alloy steel CRANKSHAFT
self-energized POWER TAKE-OFF CLUTCH
self-energized DOUBLE-DISC BRAKES —for tractors—cars and trucks

AUTO SPECIALTIES MFG. CO., DEPT., SAE-2, ST. JOSEPH, MICHIGAN

Plants also at Benton Harbor and Hartford, Mich. and Windsor, Ont., Canada.
Manufacturing for the automotive and farm machinery industry since 1908.



Twin Disc free-wheel locks impeller and turbine together to provide absorption of braking horsepower by the converter. In locking the impeller to the turbine, the free-wheel forces the truck's driving axle to turn the converter pump wheel — providing smooth, powerful Hydrodynamic Braking.

The Torque Converter with

Built-in Braking!

This Dart Model 140 mining truck (above) climbs 15% grades with 22-ton payloads in one gear—comes back down without pedal-braking—by utilizing up-to-6:1 Converter Drive and built-in Hydrodynamic Braking of Twin Disc Model CF Three-Stage Truck-Type Torque Converter (shown above in cutaway). Request Bulletin 501.

When you specify torque converters for your heavy-duty off-highway trucks, be sure to get the *extra* advantages of Twin Disc Three-Stage Truck-Type design, with *built-in* Hydrodynamic Braking *at no extra cost.*

Pioneered by the Twin Disc Clutch Company, Hydrodynamic Braking in the Model CF Torque Converter is actuated automatically when the operator lets up on the accelerator. No accessory equipment or additional cooling system for braking is required.

Here is the most effective Torque Converter downhill retarding ever developed . . . smooth, effortless braking that gives your operators *complete control all the way down.* And by combining built-in Hydrodynamic Braking with friction braking of the engine, Twin Disc offers *maximum* downhill retarding *without shock-loading the transmission.*

Add the powerful torque multiplication of Twin Disc Three-Stage design (up to 6:1 at stall, highest in the field) and you have virtual *elimination* of uphill shifting as well as of downhill pedal-braking . . . providing *faster work-cycles with more payloads hauled per day — lower ton-mile costs* — and *savings on engine, tires, brakes, and drive-line components.*

TWIN DISC

TWIN DISC

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin
Hydraulic Division, Rockford, Illinois

not, however, a separate stimulation of meetings and membership interests to give sharper focus, as there is today. Therein lies the fundamental difference between the organization of the Society as it was in 1916 and as it became in 1929.

One may still wonder why Air Transport, Engineering Materials, and Tractor and Farm Machinery did not receive Professional Activity status at an earlier date. A partial answer might be that they had first to grow to suitable stature. A much better answer is to be found concealed in a statement made by the Council in 1916 when, for the time being, it turned down the suggestion that a vice-president representing body engineering be added to the Council in accordance with the organizational plan then in effect. The Council said:

"It is the sense of the Council that the activities in question are properly provided for in the carrying on of technical sessions in body engineering, and the publishing of papers in the *Journal*, and that the creation of additional officers is not conducive to the best interests of the Society."

Here we get the suggestion of timing as an element. The Society, having the best interests of the entire membership in mind, cannot move too fast, nor too slowly. It must guard against being overly influenced by the enthusiasms of the few, and be just as careful to recognize when an interest has expanded to assume an importance equal to other interests already recognized as specialized. It is the Council's responsibility to weigh the many interests and hold them in balance for the most efficient operation and greatest benefit to the greatest number. Operating successfully in this manner, it can be truly democratic and fruitful.

So it can be seen that even as the SAE grew in breadth by recognition and inclusion of allied interests, it has always singled out and emphasized the common denominators of automotive interest. By so doing, the family unit has been strengthened.

CHAPTER IV

Peace to War— and Back Again

WHEN World War I broke out in Europe, the SAE was only nine years old, but stalwart for its years, like the industry it repre-

more dependable starting *under all operating conditions*

"No Kick-Out" feature sets new standards in starting performance.

Since the earliest days of the automotive industry Bendix* Starter Drives have been noted for reliable starting.

Now with the new and latest Bendix Folo-Thru Starter Drive, starting, even under the most adverse weather conditions, has been improved immeasurably.

Although this new Bendix Starter Drive is fundamentally similar to its illustrious predecessors, it is specially designed to follow through the weak explosions until the engine actually runs on its own power.

That's why cars, trucks and buses equipped with the Bendix Folo-Thru Drive are easier and quicker to start under all operating conditions.

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ECLIPSE MACHINE DIVISION OF Bendix AVIATION CORPORATION

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Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

Bendix folo-thru starter drive

costs less—*The new Folo-Thru Drive requires no actuating linkage and the less expensive solenoid may be placed in any convenient position. Results are lower installation costs and no adjustments. Complete detailed information is available on request.*

Bendix* Folo-Thru Starter Drive **Bendix* Automotive Electric Fuel Pump** **Stromberg* Carburetor**

YOU WOULDN'T WANT *an abrasive that lasts forever!*

For the simple reason that it wouldn't clean at all.

Abrasive economy lies in a nice balance of 1. long life, 2. cleaning efficiency, 3. low maintenance costs and 4. speed. Permabrasive annealed iron shot and grit are engineered to meet these requirements BETTER; made from chilled iron abrasives of proper composition, we KNOW and you KNOW exactly what they can do. We'll guarantee a savings over your present abrasive costs— in writing— . If we fail, we will give you a check to produce the guaranteed savings* and a test won't upset your apple cart: it is simple to make with the "electric timing device." Ask about it.

*10% in the case of Permabrasive
15% in the case of Controlled T

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sented. The peak of the cyclecar craze had just passed, manufacturers were beginning to install electric starters as standard equipment, and the sleeve-valve engine was making its first public appearance.

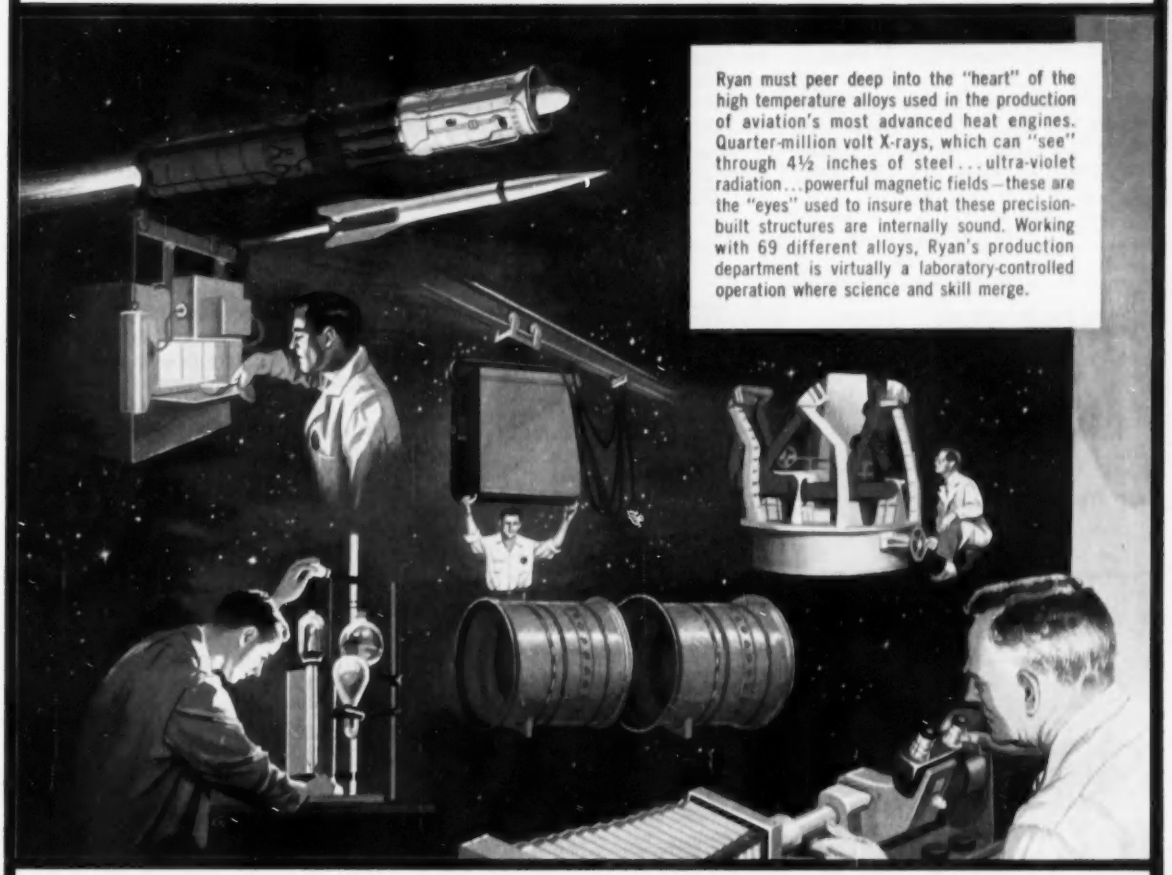
There was talk of preparedness within the Society and speculation as to the role motor vehicles might play in the conflict. After all, modern highways were just being developed, automobiles were still "pleasure cars," trucks ran on solid tires, and military transportation meant foot, horse, or mule. The Army, for its part, undertook an experiment in motor truck transportation in New York's Harlem Valley, which turned out to be unconvincing.

Preparedness talk persisted through 1915 and 1916 while business went on as usual. A flood of medium-priced eights appeared in 1916 and the following year was highlighted by a nationwide agitation against the high price of gasoline. But the SAE was looking ahead. In January, 1916, a "Preparedness Banquet" was held at which Secretary of the Navy Josephus Daniels asked for the Society's help in developing powerplants for Navy submarines and aircraft. There were going to be production difficulties, he said, because aircraft engines had no longer than a 440-hr operating life and so must be supplemented by two or three spares.

Members of the Society were soon appointed to the War College General Staff Advisory Board. Special committees were created to cooperate with government agencies. The Society's technical contribution is unfolded elsewhere, but it can be said here that the war years marked a milestone. They gave the Society what might be called its "basic training" which was to prove of inestimable value 23 years later. They made it plain to those responsible for the prosecution of the war that SAE held the key to unlock the engineering potential of the automotive industry. And, finally, it demonstrated the Society's capacity for serving industry in war as in peace.

When the clouds of World War II began to gather, the Council made a careful study of SAE facilities, then declared its preparedness well in advance of definite necessity. As a result of this official forehandedness, working relationships were established with military departments of the government, needed committees

SUPER ALLOYS **DEMAND** SUPER-VISION



Ryan must peer deep into the "heart" of the high temperature alloys used in the production of aviation's most advanced heat engines. Quarter-million volt X-rays, which can "see" through 4½ inches of steel . . . ultra-violet radiation . . . powerful magnetic fields—these are the "eyes" used to insure that these precision-built structures are internally sound. Working with 69 different alloys, Ryan's production department is virtually a laboratory-controlled operation where science and skill merge.

Another Example of How

RYAN BUILDS BETTER

Ryan's unique abilities for meeting difficult production problems are exemplified in the field of high temperature metallurgy. Here, Ryan's specialized knowledge creates parts which "live longer" in the seething infernos of jet engines, rocket motors, afterburners and exhaust systems. Advanced metallurgical research provides Ryan with intimate knowledge of the nature and behavior of even the newest, least understood super alloys. Through close integration between laboratory and factory, this knowledge becomes a basic part of aircraft production know-how.

For 32 years Ryan has been a leader in aircraft and component manufacture and design . . . and by doing more, because it understands more, Ryan continues to contribute materially to America's air superiority.

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METALLURGICAL ENGINEERING	WEAPONS SYSTEMS		ROCKET MOTORS & RAM JETS	AIRCRAFT EXHAUST & DUCTING SYSTEMS

were appointed, and the SAE was well into the war situation even before the war was actually declared.

At the 1942 Annual Meeting, the Council authorized the formation of a War Activity Council whose duty it was to coordinate the work involved in the War Engineering Program. Then, as part of the structure of the War Activity Council, a War Engineering Board was organized which comprised the best automotive engineering talent to be had. By these moves the Society was profiting from previous wartime experience, putting itself into position to handle expeditiously the great volume of work which was being generated under the War Engineering Program.

The War Engineering Board drew upon the talents and experience of members to evaluate the problems found for it by the military and to organize the subcommittees of specialists to carry out the projects necessary to solve those problems. It commanded the capabilities of the most highly qualified personnel to solve problems reported by military and civilian agencies. It made use of industry's available data, research facilities, equipment, and trained personnel. By its plan of operation it was able to bring together representatives of producing industries, of the military, and of automotive engineering, for joint explanation and understanding of any problem, and for the planning of steps most likely to lead to prompt solution.

When the Board started work it had 36 vital projects. Eventually it carried on more than 150 major projects through the cooperation of more than 600 engineers and technologists. Outstanding among its accomplishments was its work with critical materials.

The Aeronautical Division of the Standards Committee made a major contribution in developing Aeronautical Material Specifications. This has been a continuing project, gaining in stature with the years.

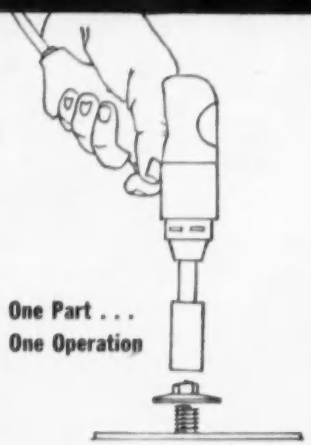
While full details of technical work accomplished under the SAE War Engineering Program must be left for a later telling, its scope is suggested by two figures. Members involved in its cooperative services totalled 3200, while the projects numbered nearly 1400.

The SAE rendered a profound service to the military and through it, to the country, but basically the service was to industry. In this respect it was no different from the contribution made in peacetime. What was different were the specific problems, the number arising at the given moment, and the urgency for their solution. The Society expedited war work by being able and ready to serve as a centralizing and coordinating agency. No wonder members were enthusiasts. Their work was facilitated, their burden lightened, and confusion routed through this unparalleled cooperative enterprise.

In 1943, while the war was still in progress, the Council decided that another critical look at the Society was in order. It appointed

SPEED UP ASSEMBLY
of
Mouldings, Nameplates, Medallions, etc.

THIS



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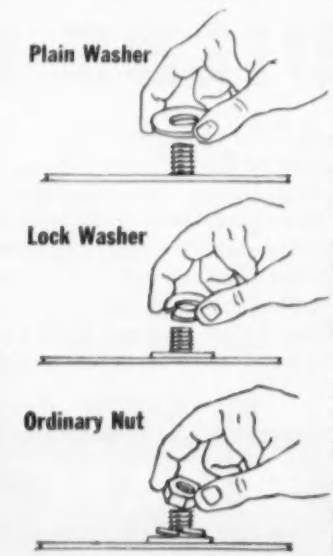
3 Parts . . . 3 Operations



REAL SAVINGS when Washer Type PALNUTS are applied to your mouldings, nameplates, medallions, deck handles, tail and parking lights, instrument mountings, etc. Also real security, due to live spring locking action. Popular thread sizes always in stock. State thread size and washer diameter or clearance around stud or bolt when requesting free samples.

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730 West Eight Mile Road, Detroit 20, Michigan
Telephone: Jordan 4-6087

WASHER TYPE
PALNUT
TRADE MARK ®
LOCK NUTS

a Post-War Advisory Committee, comprising seven past-presidents, to do the job. The Committee's assignment was to study all phases of SAE operations, looking to a smooth transition from war to peace and the development of a dynamic postwar program. It was to consider how best the Society could profit from the experience it had been accumulating, and, incidentally, make provision for continuing work with the military.

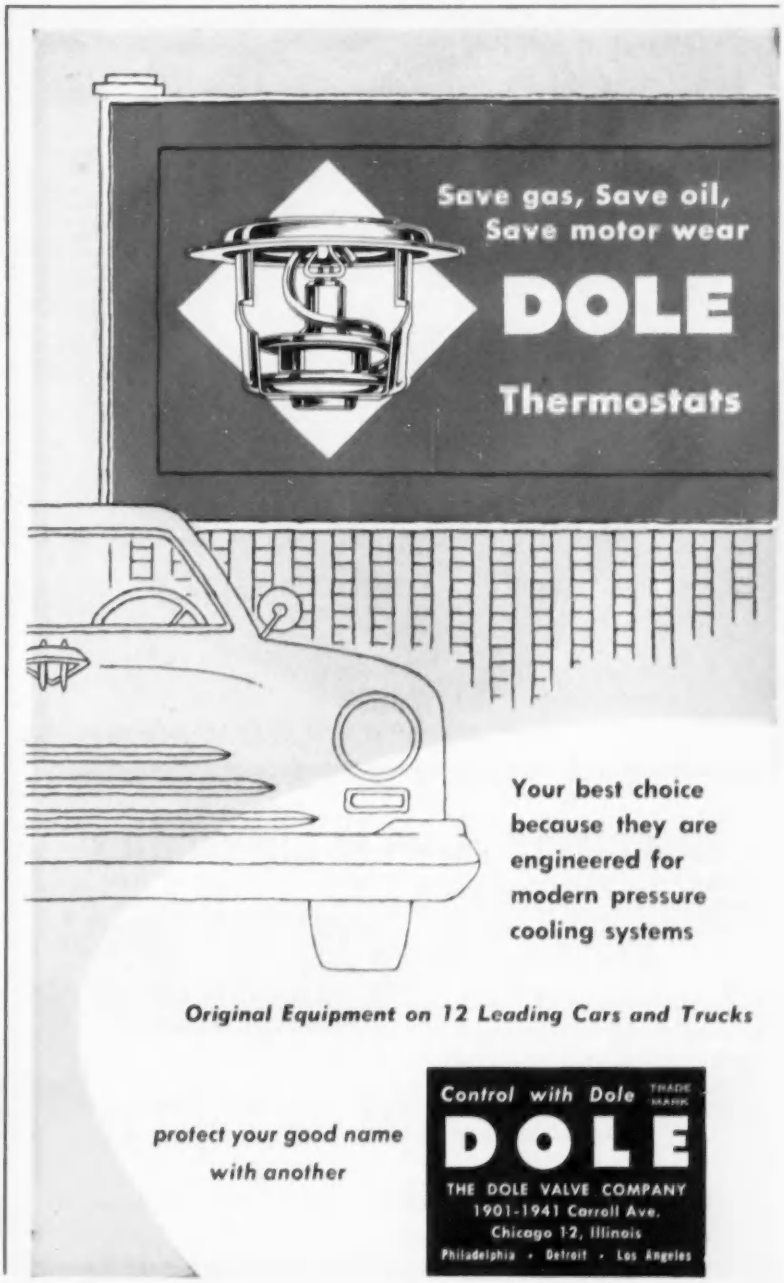
The Committee recommended, among other things, the creation of a Technical Board comprising the very best in engineering talent. This would provide the Council with a single responsible body through which to administer technical committee work. The General Standards, General Research, and Engineering Relations Committees would then be absorbed and their functions taken over by the Board, having jurisdiction over all technical committees.

The philosophy prompting this recommendation and the proposed pattern of organization derived from experience with the War Engineering Board and the Aeronautical Division of the Standards Committee. It was found to be of great value to have leadership provided by steering groups of engineers of top executive level. And to have the continuing interest and participation of these engineers. Men of this stature proved best qualified to decide what was needed to be done and to set up the programs to see the work through. Accordingly, in 1945, the Technical Board came into being.

A year later, when the Technical Board had completed its first full year of operation, it could report an integration and simplification of technical committee structure, and the taking of steps to make more effective SAE participation in the committees of other organizations. Twenty-two committees, each actively engaged in numerous projects, were reporting to the Board. Ever since, technical work has expanded and broadened as a subsequent chapter will reveal.

Within the lifespan of a single generation, the automobile was developed from nothing to a mechanism perhaps second only to the human body in its capacity to function reliably in the face of perpetual abuse. Should one seek to discover how this came about, one has only to read the publications of the Society from the earliest days to the present. Here in black and white, in ever-swelling volume, is recorded the seed of the idea, its translation into actuality, and its never-ending refinement toward the unattainable goal of perfection. It's a drama of growth and, paradoxically, one of perpetual youth.

The SAE is a family of which all members bear the characteristic features of the automotive. And just as the human family is the total of its members, so the SAE is the sum of its parts. The functioning of these parts will be discussed in detail in the following chapters, for only through an understanding of their operation can there be a full appreciation of the Society as a unified, living organism.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Save motor wear
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Something *New* in pneumatics

by VAN DER HORST

Write for additional information on this specialized application for Chromium.

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About SAE Members

continued from page 132

PETE Y. BURNS is now with the Ford Motor Co., Tractor & Implement Division, Birmingham, Mich. His new duties with the Forward Tractor Planning Department entails the planning of specifications for future tractors. He was previously affiliated with Oliver Corp., Charles City, Iowa, as assistant chief engineer.

FREDERICK J. DeWITT has been elected to the presidency of the Tropical Paint Co., Cleveland. He had been vice president of Parker Rust Proof Co. for several years. Tropical Paint is a wholly owned subsidiary of Parker.

ARTHUR E. FRIEDGEN has been elected to the new office of chairman of the board of A. E. Friedgen, Inc., New York. Friedgen is the founder and former president of the company. At the same time, **MARTIN L. ORNER**, former vice-president, was elected president.

BYRON A. FAY has retired as vice president in charge of production for the Electric Auto-Lite Co. He had been closely associated with the automotive industry for more than 50 years and had been a vice president and director of Electric Auto-Lite since 1937.

JOHN E. FAHLMAN has been elected to the newly created position of executive vice-president in the Permold Co., Medina, Ohio. He had been general manager and assistant secretary of the company since 1953.

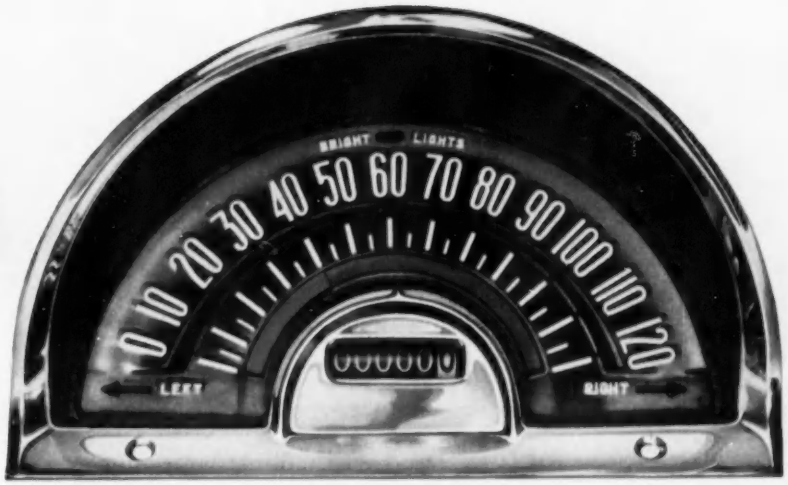
JOHN N. EUSTIS has been promoted to director of All American Engineering Co.'s Georgetown Test Base. In his new capacity Eustis will have the responsibility for the conduct of numerous test operations being carried on for the United States Navy and Air Force.

LYNDON W. BURCH, former vice-president of Control Products, Inc., Harrison, N. J., has been appointed engineering consultant with Metals & Controls Corp., (Spencer Division), Attleboro, Mass.

PAUL BUTLER BEST, JR., is now associated with Robbins & Myers, Inc., in Springfield, Ohio, as sales engineer. He previously held the position of general sales manager with Hupp Corp., Detroit, Mich.

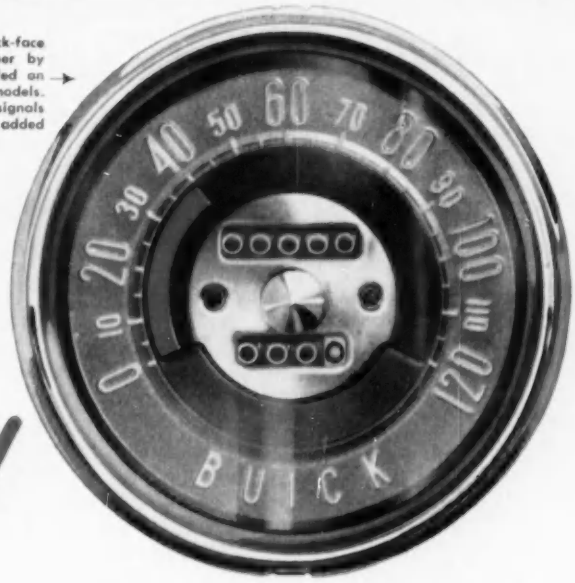
THOMAS J. CARMICHAEL has joined the field investigation department of General Motors Corp. as ad-

AC QUALITY PRODUCTS



This is the brilliant 1955 Pontiac Safety Liner Speedometer produced by AC. Traveling in a lengthening arc shape, the AC red-line indicator marks speed, gives warning.

Here is a compact clock-face version of the Redliner by AC now being installed on some 1955 Buick models. Advancing red line signals speed and signals added need for care.



FIRST and FOREMOST!

AC stresses SAFETY in NEW SPEEDOMETER Designs!

For More Than 20 Years Nearly Every Make of Car Has Used One or More AC Products

ADAPTERS (Drive) • **AIR CLEANERS** • **AIR CLEANERS AND SILENCERS** (Combination) • **AMMETERS** • **BREATHERS** (Crankcase) • **CAPS** (Radiator Pressure) • **FLEXIBLE SHAFT ASSEMBLIES** • **FUEL PUMPS** • **FUEL AND VACUUM BOOSTER PUMPS** (Combination) • **FUEL FILTERS & STRAINERS** • **GASOLINE STRAINERS** • **GAUGES—AIR** (Pressure) • **GAUGES—GASOLINE** • **GAUGES—OIL** (Pressure) • **GAUGES—TEMPERATURE** (Water, Oil) • **OIL FILTERS** (Lube) • **PANELS** (Instrument) • **RECIPROCATING VACUUM PUMPS** • **ROTARY VACUUM PUMPS** • **SPARK PLUGS** • **SPEEDOMETERS** • **TACHOMETERS** • **TERMINALS** (Ignition Wire) • **VALVES** (Crankcase Ventilation)

Last year, in its famous Redliner Speedometer design, AC broke with tradition and produced a horizontally moving red line to indicate speed and to underscore in the increasing red line the need for extra care. Today this red-area warning principle has been perfected by AC for arc- and circle-type speedometers.

Day or night this type of indicator has higher visibility, greater impact and a greater psychological warning effect. Red is a danger sign everyone knows, and AC designers use that fact to improve driving safety. The AC staff has the know-how to give you equally significant improvements in your automotive instrumentation problems. We would welcome the opportunity.

AC SPARK PLUG DIVISION • GENERAL MOTORS CORPORATION

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GM GENERAL MOTORS

ministrative engineer. He was formerly administrative engineer at the General Motors Proving Ground.

WILLIAM HUGH BOMAN has taken the position of vehicle development engineer with the engineering department of Chevrolet Division, General Motors Bldg., Detroit, Mich. He had previously held the position of test engineer with the same company.

THOMAS R. ADERTON is now installation engineer with Aero Engineering Co., Mineola, N. Y. He formerly was field engineering representative with Aero Supply Mfg. Co., Cory, Pa.

FRANK J. DOONEY has been appointed sales engineer of the Apex Smelting Co., Longbeach, Calif. He previously held a similar position with Victor Mfg. & Gasket Co., Chicago, Ill.

JOHN L. HACKER has joined the Detroit Diesel Engine Division of General Motors Corp. as project engineer. He had served in field contact engineering with GMC Electro-Motive Division.

A. D. GILCHRIST and **H. J. ZUSKE**, formerly assistant vice presidents of Leece-Neville Co., have been appointed vice presidents.

A. P. FONTAINE has been named director of engineering of Bendix Aviation Corp. He had formerly served as assistant general manager, Eclipse Pioneer Division of Bendix.

G. PETER BLOM is now branch manager with Chicago Rawhide Mfg. Co., Chicago, Ill. Until recently he was product manager with Raybestos-Manhattan, Inc., Chicago.

WAYNE N. BROWNING, who has been sales supervisor with General Petroleum Corp., is now district sales representative with the same company.

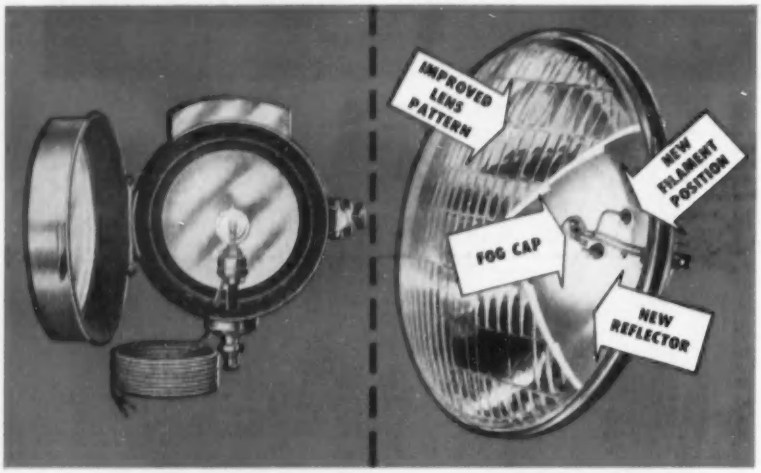
PETER L. CROWN is now associate design engineer with Lockheed Aircraft Corp. in Burbank, Calif. Previously he served as an engineer with the Armed Services Medical Procurement Agency in Brooklyn, N. Y.

ALFRED G. GORSKI is a design engineer in the Gas Turbine Division of the Lycoming Division, AVCO Mfg. Corp., Stratford, Conn. He had been chief draftsman with Alloy Engineering & Casting Co., Champaign, Ill.

ROLAND S. ELY, formerly application sales engineer for Howell Electric Motors Co., Howell, Mich., is now the owner of Ron Ely & Co., Cincinnati, Ohio. This new company is a manufacturer's agent, representing companies that manufacture production gages, tools, and parts.

A. H. SCHMAL was appointed manager of Borg-Warner Corp.'s Products Development Laboratory in Detroit. He joined Borg-Warner as chief engineer of Detroit Gear Division. Schmal succeeds **DAVID T. SICKLESTEEL**, who has been named manager of the Long Mfg. Division's new industrial sales and engineering organization.

FRANCIS C. SLOAN has been appointed to the position of chief, Motor Equipment Division, General Services Administration. Prior to this he was supervisory automotive transportation specialist in charge of the Twelfth Naval District Transportation Center, Treasure Island, Calif.



MULTIPLEX TO VISION-AID

Half A Century of Auto Lamp Engineering

Ever since the pioneer days of the electric headlamp—shortly after the turn of the century—Tung-Sol engineering has steadily contributed to the development of more efficient lamps to help illuminate greater areas of highway darkness.

From these early automotive lamp days—characterized by inadequate power storage and rough, filament-smashing roads—Tung-Sol's engineers have been solving lamp design and manufacturing problems.

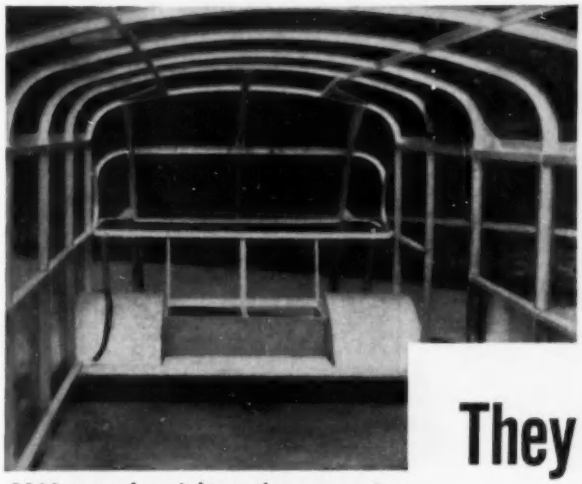
Today, in Tung-Sol's second half-century, they have produced the Vision-Aid Headlamp—embodiment of the most advanced headlamp design. Yet, Tung-Sol's engineers know that tomorrow even the Vision-Aid will be another museum piece, like its famed forebear, the Multiplex.

As a result of these years of experience in lamp design, development and manufacture, Tung-Sol is eminently qualified to help you with your lamp engineering problems.

TUNG-SOL ELECTRIC Inc.,
Newark 4, N. J.

Sales Offices: Atlanta, Chicago, Columbus, Culver City (Los Angeles), Dallas, Detroit, Montreal (Canada), Newark, Seattle.

TUNG-SOL®
AUTO LAMPS

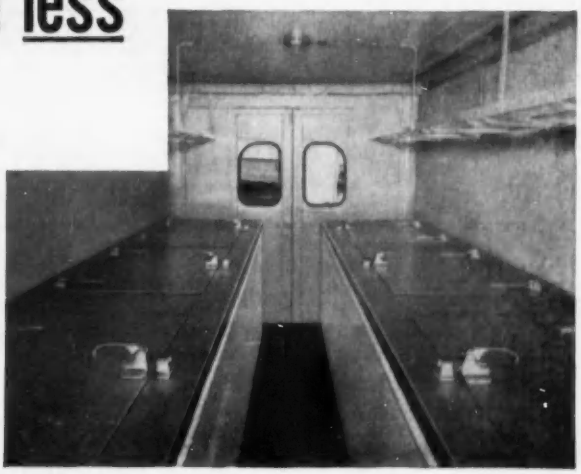


1300-pound weight saving means less wear on tires and brakes, less fuel and maintenance for this 25-passenger type bus body made by Boyertown Auto Body Works, Boyertown, Pa.

Resistant to corrosion, abrasion and impact, nickel alloy steels extend life of 17 basic bodies and more than 100 custom variations put out by Boyertown Auto Body Works.

They Haul more...yet weigh less

50% greater yield strength in sections of ¾" or less, and up to 40% more ultimate strength permit Boyertown to trim about 500 pounds from this type of parcel delivery truck, as compared with carbon steel.



The interior of Boyertown's food-handling trucks is lined with stainless chromium-nickel steel for its corrosion-resistance which assures sanitation.

You, too, can trim needless weight from truck bodies, while adding strength, toughness and corrosion-resistance

Use of high strength, low alloy steels containing nickel is the answer

You can lower haulage costs by designing to utilize high strength, low alloy steels containing nickel.

Several leading steel companies offer these steels. Look for such trade names as Tri-Ten, Cor-Ten, Mayari R, Yoloy, Hi-Steel, Double-Strength, and Dynalloy.

Get all the facts shown in "Nickel-Copper High Strength, Low-Alloy Steels . . ." a manual that is yours for the asking.

It discusses design factors that help you cut weight without sacrificing safety. It explains why these nickel alloy steels provide superior resistance to atmospheric and many other types of corrosion. It describes their behavior in fabrication, as well as applications that illustrate how they may help *you* improve products or equipment.

Take full advantage of the properties these nickel alloy steels offer . . . write for your copy of "Nickel-Copper High Strength, Low-Alloy Steels" now.

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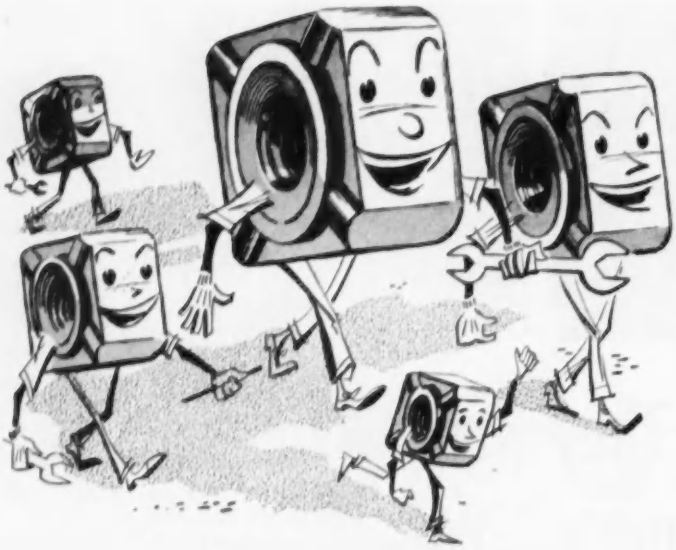

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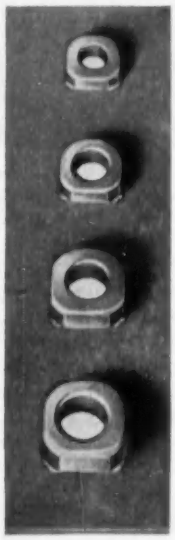

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Power Steering Pot Still Boils Verbally

Based on paper by

R. A. GARRISON

Garrison Mfg. Co.

THE big questions debated by designers and manufacturers of power steering center around steering effort—to what point should effort be reduced, how obtain the greatest amount of recovery, how put "feel" back into the steering wheel and how low an effort in some cases will effect recovery.

There is also industry-wide discussion on the relative merits of different types of steering, i. e., the installation problems of the gear and varied linkage types. In some cases the integral gear type sticks out in the wrong places, while the linkage type poses the problem of flexible hose location.

The air operated unit can get power from existing air compressors. However, power must be adequate to supply both steering and brakes. It has some installation and power limitations because the source is within the range of the compressor. Hydraulic power, on the other hand, ranges from 750 to 900 psi, hence cylinder size may be reduced. (Paper "Recent Developments in Power Steering" was presented at SAE National West Coast Meeting, Los Angles, August, 16, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

How to Pin-Point Preignition and Knock

Based on paper by

R. C. BOWERS

and

A. R. ISITT

Shell Development Co.

TECHNIQUES used for observing preignition and knock generally employ audible and instrument methods. All of them have value, but the problem is difficult because a transient phenomenon must be observed in as many as eight cylinders at a time.

To obviate this difficulty, a new technique has been developed in which instrumentation is designed to respond to the external vibrations of an engine caused by either knock or preignition.

The complete instrumentation consists of a multicylinder knock analyzer, a recording translator, a dual channel magnetic tape recorder and a special camera. In operation, the output from

"LOOK WHAT'S HAPPENED TO THE GEARSHIFT!"

says William Lundigan (*Your host on "Shower of Stars" and "Climax!"*)*

1. **"BACK IN GRANDDADDY'S** day you needed a long reach, a strong arm and a third eye to shift gears. The gearshift was outside the body of the car, where it was a tempting toy for the neighborhood kids.

2. **"I REMEMBER IN DAD'S** first car, the gearshift had moved in out of the rain, but in everybody's way. Rising like a flagpole from the floor, it tangled with legs, hands and handbrake. If you sat three in front—oh, brother!

3. **"NEARLY 20 YEARS AGO** it moved to the steering post. With automatic shifting it *stayed* on the post! *Now* Chrysler Corporation's PowerFlite transmission makes possible a *more convenient, more fool-proof* location!

4. **"TODAY—WHERE IT BELONGS!** In its beautifully-styled 1955 cars, Chrysler Corporation has put the Selector right next to the ignition key, on the instrument panel! I like it there; so does everyone else who has tried it. You flick your PowerFlite Range Selector to "D" and off you go—with the smoothest automatic transmission of all! It's simple, convenient—and out of the way. After all, with PowerFlite transmission, you rarely have to use the Selector! This is one of the many Chrysler Corporation exclusives that you'll find in cars with THE FORWARD LOOK. Take my advice: why not see THE FORWARD LOOK at your dealer's today?"

**See Chrysler Corporation's great new TV shows—"Shower of Stars" and "Climax!" Thursday, CBS-TV, 8:30 P.M., EST.*

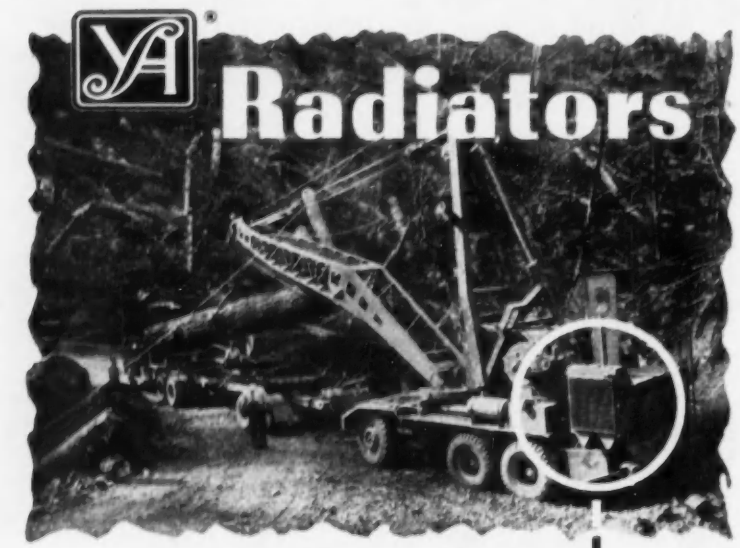
PLYMOUTH · DODGE · DE SOTO · CHRYSLER · IMPERIAL

CHRYSLER CORPORATION — **THE *FORWARD* LOOK**

Copyright 1954, Chrysler Corporation

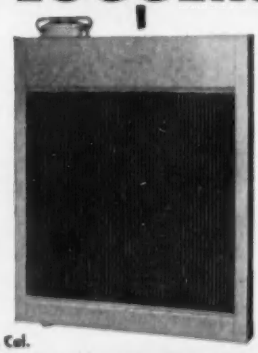
a magnetostriction pick-up is impressed onto an oscilloscope screen and knock and preignition are differentiated on a basis of the time elapsed since the ignition spark jumped. To permit identification of the preigniting or knocking cylinders, individual sweep patterns for each cylinder are shown on the screen. To record the transient preignition phenomenon, tape recordings of the oscilloscope signals are made and played back for further study. If more detailed evaluation of selected test sections is wanted, photographs are made of the oscilloscope pattern from the played-back tape. A strip camera of simple design is used for this purpose.

Any vibratory event, anywhere in the engine, such as valve noise, piston slap, bearing knock, combustion noise or preignition, which occur during the 120-deg immediately following ignition, will show up on the trace of that cylinder. It is possible, for example, to make up a chart for a given engine showing valve operation versus crank angle to enable the instrument to be used diagnostically to locate noisy or malfunctioning valves. (Paper "The Observation of Automotive Preignition and Knock" was presented at SAE Summer Meeting, Atlantic City, June 10, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)



. . . provide efficient cooling for these
GIANT MOBILE LOGGERS!

WHERE the going is rugged . . . that's where you'll find Yates-American Radiators on the job! Typical is this scene of a Giant Mobile Logger working in the big timber in Rose Valley, Washington, yarding and loading on a salvage operation. Radiator equipment must have extra structural strength as well as efficient cooling characteristics. For information on YA Radiators for your equipment, write Yates-American.



California Representative: E. E. Richter & Son, Emeryville, Cal.

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Heat Transfer Products Division
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Test Track Serves Agricultural Machines

Based on paper by

W. J. COX
Massey-Harris Ferguson Co

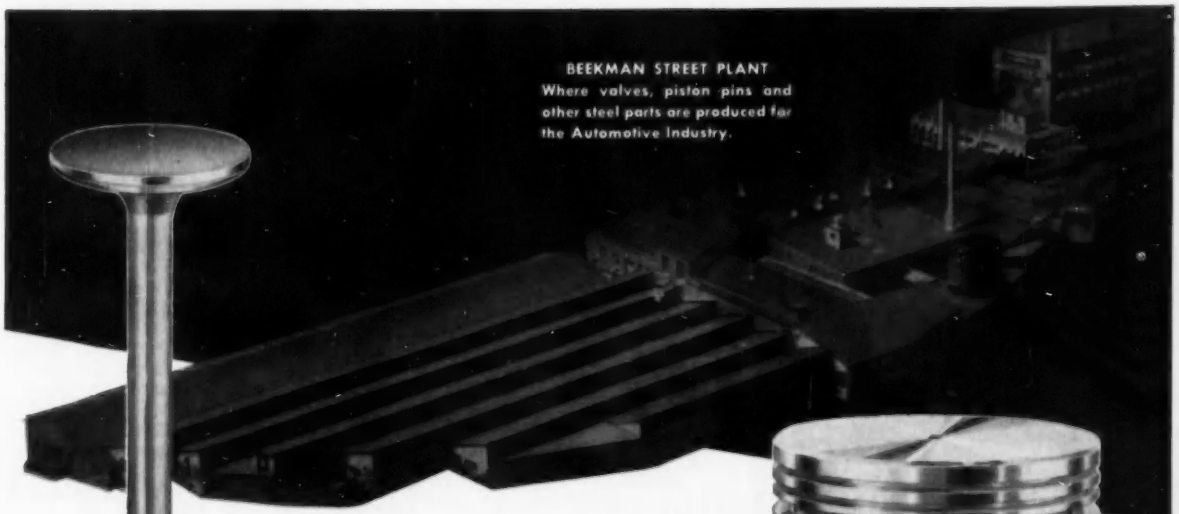
THE main uses of the test track in the agricultural machinery field are:

1. Testing engineering prototype machines for comparison with proven production machines.
2. Testing factory machines to check on manufacturing standards.
3. Providing a test ground for controlled experiments during which actual performance is measured scientifically with instruments.

Failures of machine parts can be attributed generally to fatigue or wear. In fatigue failures, progressive fracture may occur well below the yield strength without measurable plastic deformation under the action of repeated loadings. The problem of providing fatigue strength in excess of operating conditions, and retaining a minimum structural weight at the same time, is one of the main design considerations.

Researches on fundamental fatigue problems are being carried on in laboratories all over the world. But at the present time, the basic material with which an engineer must face design problems involving considerations of fatigue will be empirical and derived from test on idealized specimens. Theoretical calculations are necessary but in many cases they are not applicable. Notch sensitivity in fatigue is governed by so many factors that calcuation often serves only as a guide. Only the part itself, made of the material to be appraised, gives a final answer. Notch effects are dependent on size, that is, the larger the specimen the more chance that a weak spot will be present. A shape effect is also present; square or rectangular sections give lower results than round ones.

Geometric stress concentrations are influenced by the choice of material. A severely notched part may show little or even reduced life made from improved material. Surface conditions have considerable effect on endurance. Cold work and some heat treatments may provide a compressive stress on the surface which subtracts from the



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Where valves, piston pins and other steel parts are produced for the Automotive Industry.

ALUMINUM INDUSTRIES inc.

marches forward with the automotive industry

As a regular supplier of pistons, valves, many types of steel parts and aluminum castings to automotive manufacturers, Aluminum Industries, Inc. shares in the responsibility for continually giving the automotive buying public a better product.

Aluminum Industries was among the first to develop aluminum pistons for automotive engines. Since those early days we have steadily augmented our production and technical facilities to do our part in helping the automotive industry achieve its yearly goals of finer performance and better values.

Your inquiry is invited.

ALUMINUM INDUSTRIES inc.

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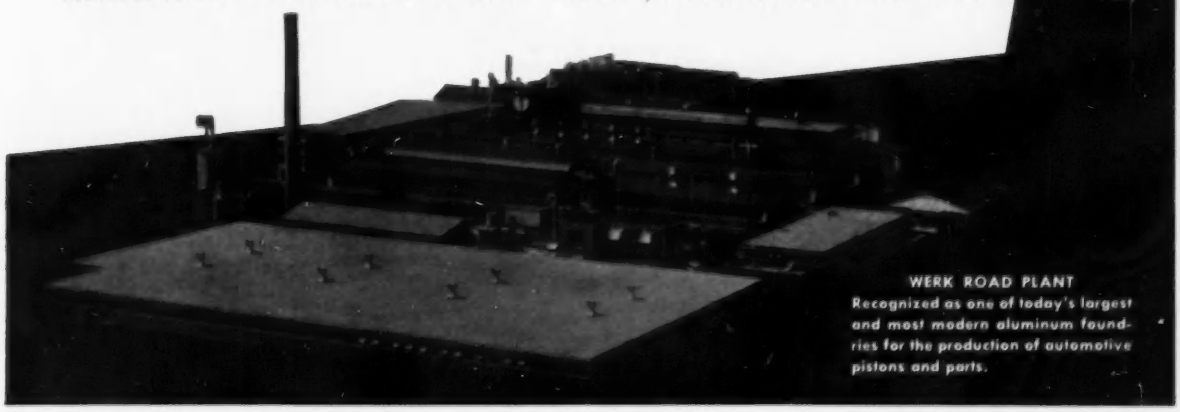
ALUMINUM PERMANENT MOLD AND SAND CASTINGS • HARDENED, GROUND AND FORGED STEEL PARTS



WERK ROAD PLANT
Recognized as one of today's largest and most modern aluminum foundries for the production of automotive pistons and parts.

overall tension stress so that the actual surface stress is reduced. Other surfaces, such as rough machining, or forging, decarburization, corroded areas, and even chrome plate reduce the endurance. Weldments provide other points of fatigue weakness.

On the test track, a type of simulated service testing is possible by operating the vehicle in transport position. This is the normal operating condition for many machines such as combines, balers, and manure spreaders. Machines such as plows may have more severe loading in some components in the transport position than in the working position. Plows, cultivators, and wheeled disc harrows have to withstand towing at moderate speeds in the transport position behind tractors and even trucks. No attempts has been made to apply load to tool holders on tillage implements for endurance testing. Impact and working loads have been measured using resistance wire strain gauges.

In the development of engineering prototypes, designers should purposely design their machines lighter and, after the machine is built, strengthen the weak points as they show up. It is seldom possible to reduce the size of a member in a machine after it is designed.

Flexibility in the design of machine frames has shown advantages in that the structure deforms to prevent individual members from loading up. Flexible frames are not always possible because of other requirements. Transition from a rigid to a flexible structure requires careful attention to design detail. (Paper "Proving Agricultural Machinery on a Test Track" was presented at SAE National Tractor Meeting, Milwaukee, Sept. 15, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Based on Discussion

R. W. Sohl, Goodyear Tire & Rubber Co.

Are combines tested with loaded bins? Does tire failure occur on test or track?

Cox: Tests are normally conducted with one-half bin load. Under draft load we do have premature wear on tires, especially on tractors. Wear is not great on free rolling tires. Some failures occur on Belgium block tests.

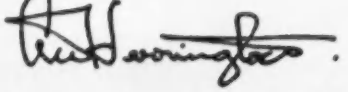
MARMON-HERRINGTON Congratulates the SAE On Its Golden Anniversary

It is an honor to salute the Society of Automotive Engineers for the signal service it has rendered to the economic development and well being of the automotive industry, the nation and the entire free world.

The SAE Standards Program alone has done much to stabilize the automotive industry, helping to standardize parts and components, improve quality, lower costs and reduce inventory stocks.

At the same time, SAE technical advisory committees, in close cooperation with military engineers, have played a major role in the development and refinement of all types of military vehicles.

The SAE may well be proud of these and other achievements, and the public grateful that such an organization labors constantly in its interest.



Specialized Manufacturers of Commercial and Military Vehicles • All-Wheel-Drive Trucks Trolley and Motor Coaches • School Bus Chassis

MARMON-HERRINGTON
Indianapolis, Indiana

How to Improve Tractor Seat Design

Based on paper by

DR. ING. MAX HAACK

Institute for Tractor Research
Agricultural Research Center
Braunschweig-Völkenrode, Germany

Complete paper will appear in 1955 SAE Transactions

"BOTTOMING" of a tractor seat can be avoided if, in addition to the static deflection due solely to the weight of the motionless driver, a supplementary deflection in the order of 1½ times that of the static deflection is available.

Compensation must be provided for the widely varying weights of drivers. Seat springs should not be preloaded, but their course of action should be varied in such a way that the seat suspension characteristics are changed while the static deflection remains constant. Only this way can a favorable natural frequency of the seat be maintained.

It is very important to reduce the impact of the driver as he lands on

We grew up with the Automobile Industry

GROWING UP TOGETHER, working together for more than fifty years, the automobile builders and Johnson Bronze have made tremendous progress. Engineering cooperation made possible higher compression, higher speeds, and greater durability in automobiles. The same cooperation developed changes in bearing design, new conceptions of precision, refinement of alloys and new bearing metals. As a result, today's Johnson Automotive Bearings are better than ever.

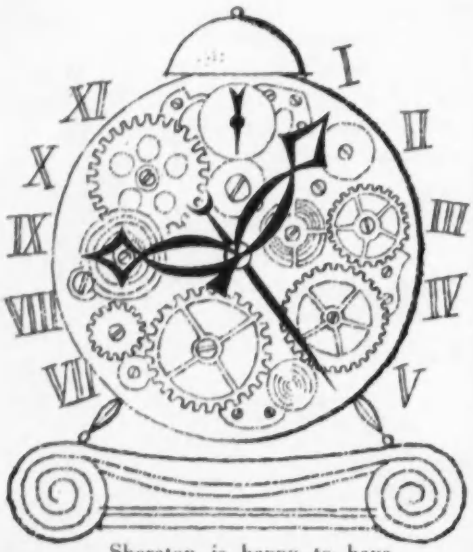
JOHNSON BRONZE COMPANY
675 South Mill Street, New Castle, Pennsylvania

JOHNSON JB BEARINGS
Sleeve-Type

the seat after being pitched from it. Steps to end this include: reduction in the oscillating mass of the seat, padding, and damping of the seat suspension with a suitable shock absorber, or through the use of high damping quality material such as rubber.

The investigations into seat design for passenger cars made by W. E. Lay and L. C. Fischer are of only limited value to tractor seat design. Their report indicates that a back rest cushion sloping backwards and extending to the height of the operator's shoulders gives the most comfortable sitting position. The sloping position is totally unsuited to the tractor driver because of pitching. The distribution of load acting against the seat of a passenger car does not apply to the seat of a tractor because the driver is bending forward. The padding of a tractor seat should not be uniform in thickness. The suspension in the center of the area supporting the driver's weight should be from three to four times stronger than at the sides. The distribution of the pressure on the seat may be assumed to be parabolic.

The tractor driver's body must be supported at the pelvis and not at the shoulder blade area, because the inherent flexibility of the spine does not afford the necessary rigidity against bending. Hence, a low back rest built up to the height of the pelvis seems to be the most favorable design. (Paper "Tractor Seat Suspensions for Easy Riding" was presented at SAE National Tractor Meeting, Milwaukee, Sept. 16, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)



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Sheraton is happy to have welcomed you at the Sheraton-Cadillac.

Like members of the SAE, we're engineers of a sort, too. Convention engineers. We've spent years fitting together all the parts that go into a smooth-running show.

From Boston to California, in Canada, too, you'll find Sheraton Hotels carrying on the tradition. We hope our hotels will be rolling out red carpets for you for many years.

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CINCINNATI Sheraton-Gibson
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Variable Speed Drive Proves Out on Tractor

Based on paper by

J. R. THOMAS
Thomas Hydraulic Speed Controls, Inc

BELIEVING that an automatic transmission would perform well in agricultural machinery having constant speed engines, provided it had suitable control, experiments were conducted with a Hydra-Matic transmission using a VariDRAULIC drive as the control unit.

Dynamometer tests were undertaken using an engine with its governor adjusted for a no-load full throttle speed of 1750 rpm, and 1700 rpm at 120 ft lb load, at full throttle to power the drive with its output shaft coupled to the Hydra-Matic's input shaft.

These tests being satisfactory, it was decided to install such a system on a 1952 Oliver "55" for field test. Fig. 1 shows the installation as it approached completion.

The engine is raised about 7 in. to facilitate placing the automatic transmission directly above the standard transmission and final drive. The VariDRAULIC drive is coupled directly

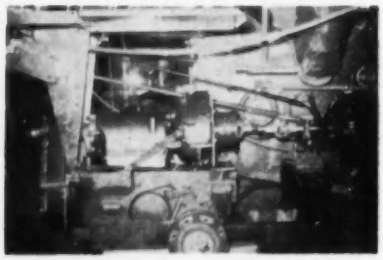

Fig. 1—Installation of a Hydra-Matic transmission under the control of a VariDRAULIC drive gives this tractor automatic shifting under power. The engine is operated constantly at full throttle

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to the engine, eliminating the traction friction clutch. The engine runs at 1800 rpm under load. A double U-joint propeller shaft couples the VariDRAULIC output and Hydra-Matic input shafts. A No. 60 roller chain drive connects the Hydra-Matic output to a special input shaft used in place of the standard counter shaft. The standard gear shift lever is eliminated. All gears were removed from the standard transmission except those used for 3rd and 6th gear, this auxiliary shaft being used to obtain a higher road speed than was available with the Hydra-Matic.

Both dynamometer and field tests showed that the following results could be obtained:

1. The operator could select a "top" gear and the load would always be started in first gear. The transmission would then shift automatically under power through successive gears, as controlled by the VariDRAULIC, until such "top" gear was reached, the engine being operated constantly at full throttle.

2. The operator could change such "top" gear "on the go" to a selection of any other gear.

3. The drive would provide stepless variable speed within any gear, the transmission automatically up-shifting or down-shifting to other available gears if the variable speed within one gear was insufficient.

4. Dynamic braking would be provided at the top of any selected gear and the selection could be changed suitably "on the go."

5. The automatic transmission had its "neutral" to eliminate adverse effects of residual torque present in hydraulic couplings.

6. The indicated efficiency of the system and its ability to shift under power would increase considerably the utility of a machine so equipped.

The machine harvested 200 acres of wheat in Oklahoma, 250 acres in Kansas and 220 acres in northwest Kansas and eastern Colorado, all standing grain. It has also threshed 365 acres of windrowed oats, wheat and rye in South Dakota. At no time has down time or repairs of any kind been chargeable to this new traction system. (Paper "Variable Speed Drives for Agricultural Machinery" was presented at SAE National Tractor Meeting, Milwaukee, Sept. 16, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

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V-Belt Drives Merit Wider Use

Based on paper by

WILLIAM SPENCER WORLEY

The Gates Rubber Co.

Complete paper will appear in 1955 SAE Transactions

THE designer of an adjustable speed propulsion drive for farm implements must keep two problems in mind—he must provide means for setting the output speed of the drive at a desired point, and for the disks of the two sheaves to move in such a way as to maintain proper belt tension.

On machines with an engine furnishing power both for propelling the machine and for performing some other function it is desirable usually to set the engine speed to that of the other function and control the ground speed at constant engine speed. It was, in fact, the requirement for small increments in ground speed at fixed engine speed which led to the first V-belted self-propelled combines.

There are machines, such as tractors, which might be V-belted and which might have an engine primarily for propulsion. Here it is often desirable to control the ground speed by throttling the engine. Many designs have been worked out for drives in which the position of the belt in the driver sheave is determined by a centrifugally loaded arrangement, such that the higher the engine rpm the further out the belt will tend to ride. In one such arrangement the drive sheave is urged to a normally closed position by a spring which serves to maintain drive tension. Such drives are widely used on motor scooters, but could conceivably have even wider application on light tractors.

On a machine such as a combine, where it is desired to control the ground speed at a fixed engine speed, it is necessary to provide some means of fixing the belt diameter in one sheave. This may be done in one of three ways: (1) through a mechanical linkage, which is still common; (2) through a hydraulic positioning cylinder, which is being used to a greater extent as hydraulic cylinders take over other such lifting and pushing jobs as positioning the header on a combine; or (3) through an electric motor driving a positioning device, which has not yet been done to our knowledge on production machines.

It has been found desirable to fix the diameter of the driver sheave in preference to the driven sheave, since under heavy overloads the belt will pull down into the sheave which is not positively located. If it can pull into the driver, then speed drops off just at a point where maintaining speed is important. If, on the other hand, the belt can pull into the driven sheave, then the speed tends to increase.

With the position of one sheave positively controlled, it is necessary next to provide means so that the belt will be properly positioned on the other sheave to maintain belt tension. One way to handle this problem is to replace the centrifugally loaded sheave with one which is positively adjusted by mechanical or hydraulic means. The spring then forces the belt to ride at a diameter which is consistent with the diameter of the positively adjusted sheave and the spring force available to tension the belt. This is a widely used method.

There is another arangement which does have some advantage over the spring arrangement, although it is somewhat more complicated and sensitive to adjustment. The linkage is almost a solid one. There is, however, a spring interposed at some convenient point which must compensate only for the difference in lateral movement of the disks, which is not very great. This makes it possible to use a short, stiff spring to good advantage. One design uses the elasticity of the linkage itself successfully.

The adjustable speed V-belt drive lends itself to a simple method for clutching. This method is simply to incorporate a free-running idler, slightly smaller in diameter than the diameter at the bottom of the groove, into the hub of the movable disk of the driver sheave. After the sheave disk has been moved into the low speed position, further axial movement of the

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disk allows the belt to ride on the idler, and disconnects the belt from driving engagement with the sheave. This method of clutching has been used successfully on several production combines. (Paper "Designing Adjustable-Speed V-Belt Drives for Farm Implements" was presented at SAE National Tractor Meeting, Milwaukee, Sept. 16, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Farm Tractor Tires Undergoing Field Test

Based on paper by

F. C. WALTERS

and

J. K. JENSEN

John Deere Waterloo Tractor Works

TESTS under controlled laboratory and actual field conditions are being conducted by the Tractor Tire Subcommittee of the Tractor Technical Committee to determine the feasibility of providing a number of series of tires such that the basic tire and at least two oversizes in each series shall have common overall diameters and rolling radii.

Data obtained at the USDA Agricultural Tillage Laboratory at Auburn, Ala. will be used by the SAE subcommittee to supplement and verify field test data.

Instrumentation which provides a high degree of satisfaction in the laboratory has been found totally inadequate in ruggedness for field test. A continuing problem of major magnitude has been to build a sufficiently high degree of ruggedness into instrumentation to withstand field test conditions for the required length of test work. Instruments must be readily portable and it is highly desirable that they and their recording means be a self-contained unit capable of direct mounting on tractor or implement.

The tractive units used for the field tests are a John Deere Model 70 and a Massey-Harris Model 55 tractor, with the following equipment:

1—Drawbar load measuring devices, employing SR-4 strain gages in a Wheatstone bridge, which measure both vertical and horizontal components of the drawbar force.

2—Conventional strain gage torque meter for determining force input to drive wheels.

3—Distance measuring devices.

4—Engine tachometer.

5—Device to measure amount of weight transferred to the rear wheels as a result of the applied drawbar load.

6—Device for measuring force required to push the front wheels to the tractive unit.

7—A magnetic counter for measuring time.

It is believed that the instruments are well adapted for the SAE tractor tests. They measure more quantities which affect tire performance than have been measured in previous tests. Their simplicity, compactness, and ease of operation make them particularly suited to any field test where average loads are desired. (Paper "Instrumentation for Evaluating the Operating Performance of Farm Tractor Tires" was presented at SAE National Tractor Meeting, Milwaukee, Sept. 16, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on discussion . . .

R. W. Sohl

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We record integrated drawbar pull, slip, distance travelled, and time, by means of electric counters and a stop watch, all controlled by a master switch. Instruments are mounted in the cab of a dynamometer truck which supplies the resistance load, controlled by the truck driver, while an engineer observes and records data.

The test tractor is connected to the truck by a tubular steel drawbar which permits the truck to push the tractor for rolling resistance and zero slip measurements.

This outfit is used frequently for tests of consumers' tractors hence the equipment must be readily mounted on any tractor with a minimum of time and special fixtures and without tractor modification. The dynamometer unit needs fair road ability as it may travel long distances.

George F. Mullin

Firestone Tire & Rubber Co.

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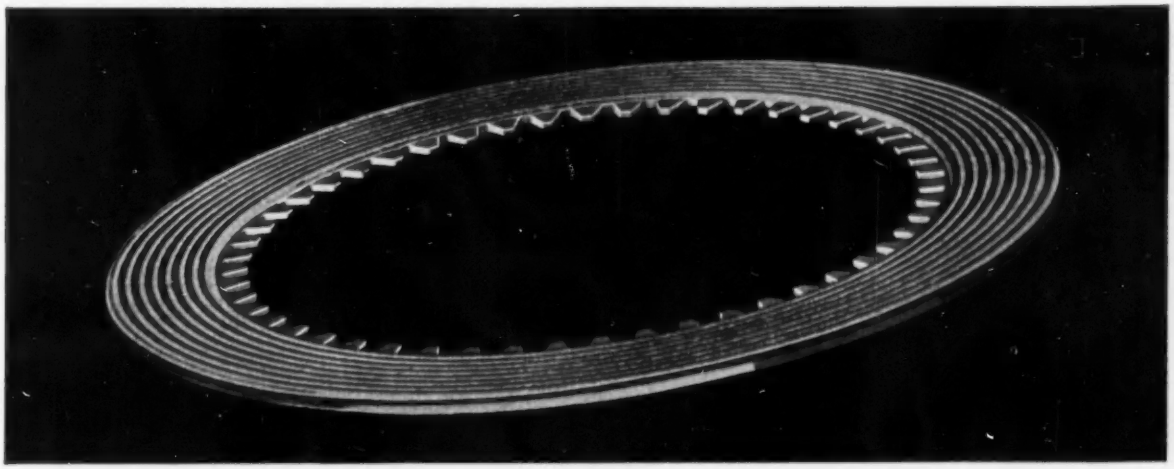

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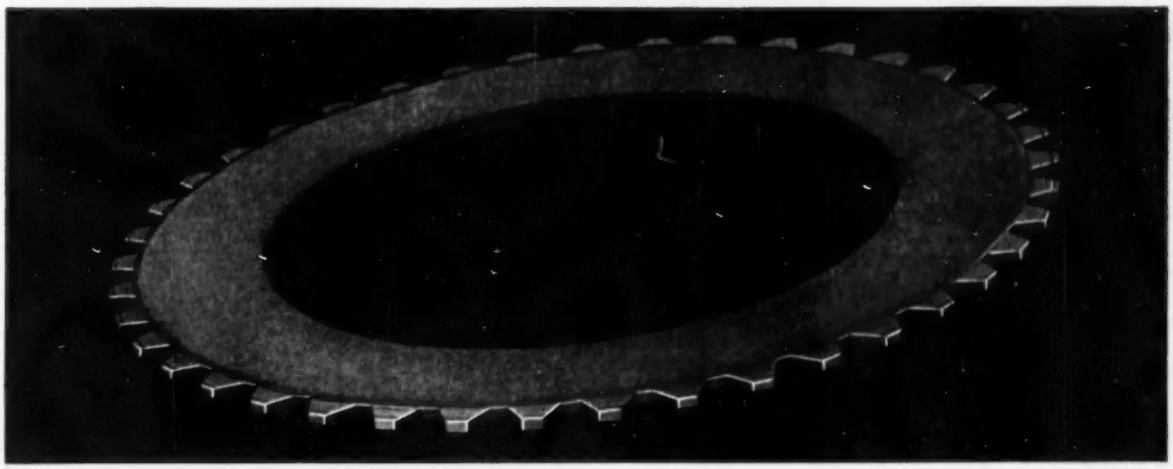

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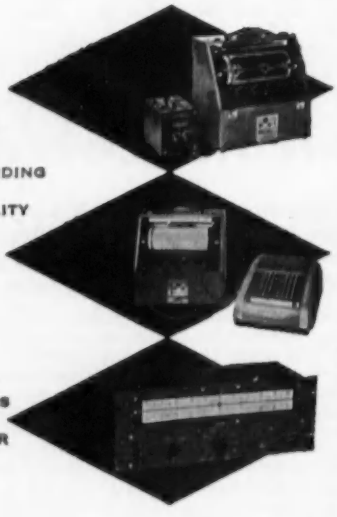

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These applicants qualified for admission to the Society between December 10, 1954 and January 10, 1955. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

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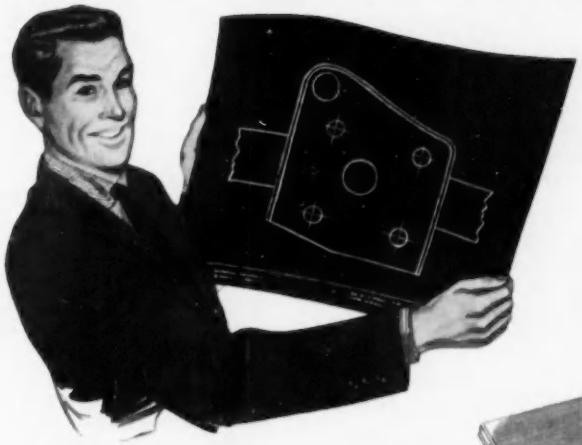

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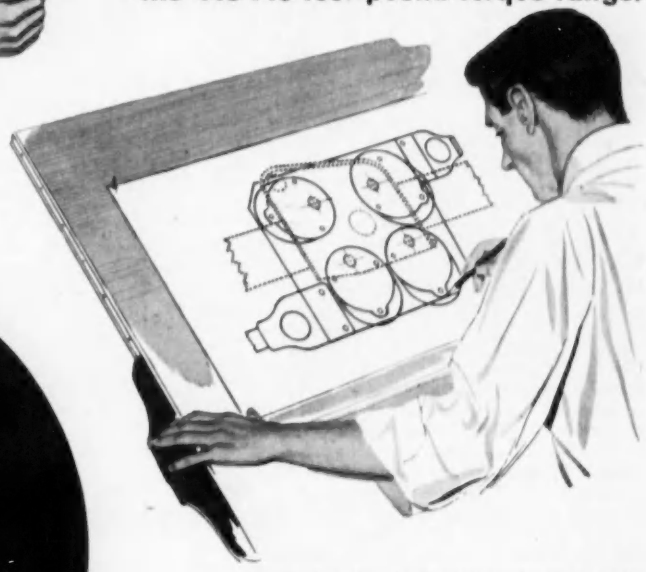

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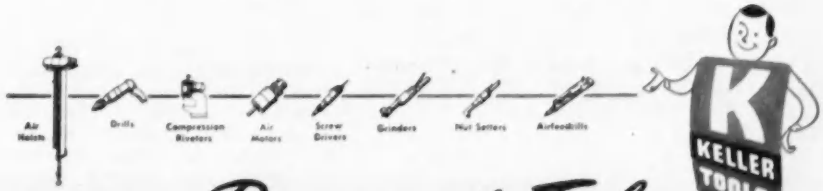

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Dr. Giulio Alfieri (M), Italy; Fred K. Al-Khudairy (J), Iraq; Juan A. Brochiero (A), Argentina; Brij Mohan Chhabra (J), India; Herbert George Freeston (M), England; Masao Ito (M), Japan; Kamalaksh Pai Kasturi (J), India; Jose Higinio Monserrat (M), Argentina; Raymond Nivet (M), France; Dodla Gopala Krishna Reddy (J), India.

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Applications Received

The applications for membership received between December 10, 1954 and January 10, 1955 are listed below.

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George M. Hett.

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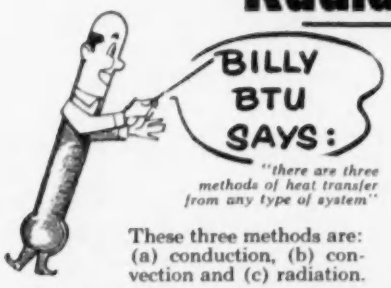
Young Heat Transfer News

YOUNG RADIATOR COMPANY, RACINE, WIS.

Navy Selects Young Engine Cooling Radiators for Mobile Jet Starters



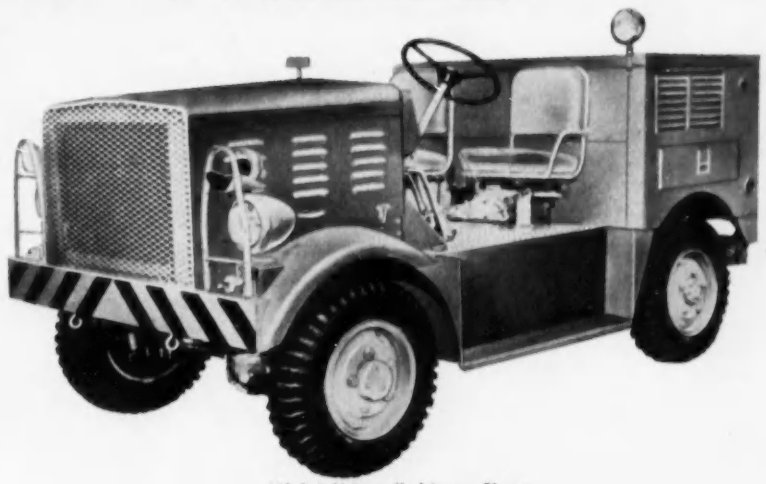
"there are three methods of heat transfer from any type of system"

These three methods are: (a) conduction, (b) convection and (c) radiation.

Heat transfer by conduction exists when heat flows within a body from one region of high temperature to another region of lower temperature by simple molecular communication. The amount of heat which can be transferred by conduction is dependent on the temperature difference, thermal conductivity of the material through which the heat is being conducted, the distance between the hot source and the cold sink, and the cross sectional area for heat flow.

Transfer of heat by forced convection depends on the velocity of the fluids over the surface through which heat is conducted . . . by the shape of the surface, by the area through which heat is conducted . . . and by various properties of the fluid as well as temperature difference.

The third general means of heat transfer is radiation. Here heat flows from the body of the higher temperature to the body of the lower temperature through space without any medium within the space. For further details on this subject write for free bulletin: "Heat: Forced Convection Removal From Industrial Hydraulic Circuits" to Young Radiator Company, Dept. 115-B, Racine, Wis.

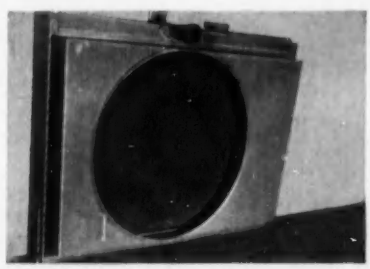


NC-5 Self-Propelled Power Plant

NC-5 Self-Propelled Power Plants are being built for the United States Navy and United States Air Force by prime contractor Consolidated Diesel Electric Corporation, Stamford, Connecticut. The vehicle is used to supply electric current for starting, towing and servicing Navy and Air Force jet planes. Its maneuverability, flexibility and speed of starting or servicing a line of planes offers many advantages over stationary or trailer types of power equipment.

Young Radiator Company fabricated Radiators for cooling the engines of these highly-specialized vehicles.

Radiator design was important because the vehicle's engine drives the 37 kw generating unit while the vehicle is at rest. The Young Radiator is constructed as an extra rugged unit with copper fin and tube core, drawn brass top and bottom tanks, and sturdy sheet metal reinforcing side members.



Rear view Young Radiator used on Navy vehicle

For further details on Young Radiators write Young Radiator Company, Dept. 115-B, Racine, Wisconsin.

NEW FIXED TUBE BUNDLE HEAT EXCHANGER CATALOG

A complete description of stock and specially engineered Young Radiator Company Type "F" Fixed Tube Bundle Heat Exchangers is given in the newly revised Catalog No. 2154. For your copy, write Dept. 115-B, Young Radiator Company, Racine, Wis.

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Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY

Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.

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for passenger car and light commercial use

RIGIDITY—The special Spicer design and construction maintain accurate alignment of gears and bearings under all speeds and loads, assuring continued quiet operation.

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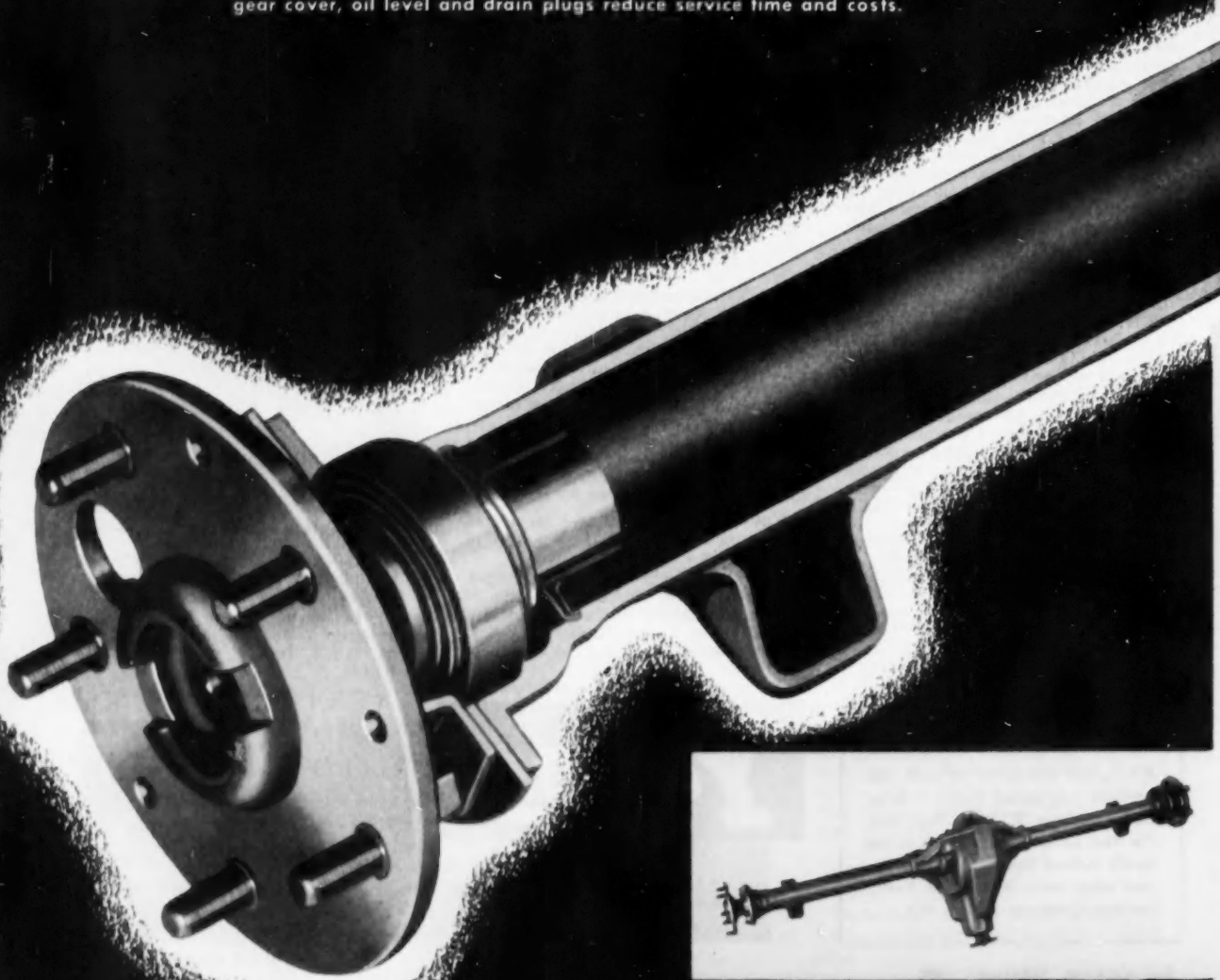
RUGGEDNESS—Sturdily constructed to withstand the high speeds and extremes of punishment which are common in modern automotive vehicle operation.

ACCESSIBILITY—Extremely easy to get into for inspection of parts. Simple-to-remove gear cover, oil level and drain plugs reduce service time and costs.



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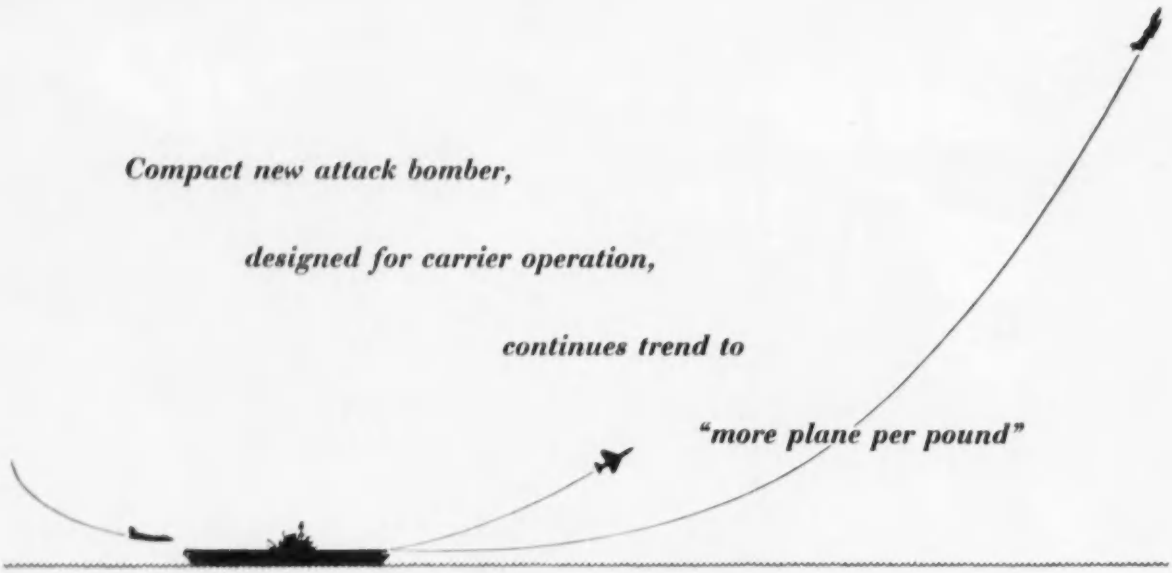
Compact new attack bomber,

designed for carrier operation,

continues trend to

"more plane per pound"



–the U. S. Navy's Douglas A4D Skyhawk

Continuing a growing trend, the Douglas A4D attains maximum efficiency—at lower production cost—through highly simplified design.

Faster than many of today's fighters, the Douglas A4D attack bomber is so compact that it can operate from carriers without folding its wings, giving a consequent reduction in weight, cost, and fuel consumption. In all respects the Skyhawk meets, and more than meets, demands on range, climb, armament, and load-carrying flexibility—exemplifying the Douglas philosophy of more performance per pound of airplane.

Performance of A4D shows Douglas leadership in aviation. Planes that can be built in quantity to *fly farther and faster with a bigger payload* are a basic rule of Douglas design.

Be a Naval flier—write to Nav Cad, Washington 25, D. C.

Depend on *DOUGLAS* First in Aviation

"Wagner Air Brakes have averaged 200,000 miles of service without any major compressor maintenance cost."*

* Says: WALTER SAYLES, Superintendent of Maintenance
MORRISON MOTOR FREIGHT, Inc., Akron, Ohio

It's a matter of record, from hundreds of case histories, that WAGNER AIR BRAKES render the reliable safety-proven performance fleet operators demand. This dependability is the result of more than thirty years' experience in manufacturing brakes and complete brake systems. The advantages of WAGNER AIR BRAKES gained by Walter Sayles of Morrison Motor Freight, Inc., are indicative of this outstanding record.

WAGNER AIR BRAKE SYSTEMS are available either as "straight air" or "air-over-hydraulic," and all feature the WAGNER ROTARY AIR COMPRESSOR. Learn for yourself why more and more safety-minded, cost-conscious fleet operators are specifying WAGNER AIR.

Because of the ever-increasing demand for greater road and cargo safety and maintenance economy, it will pay you to include Wagner Air Brakes as standard equipment on the vehicles you manufacture.

Send for your free copy of Wagner Bulletin KU-201 for full information and complete details. It will be sent to you without cost or obligation. Mail your request, today.

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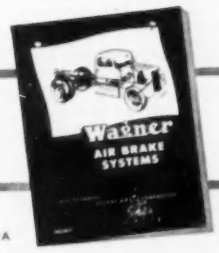
Sincerely,

Walter Sayles

Walter Sayles
Superintendent of Maintenance



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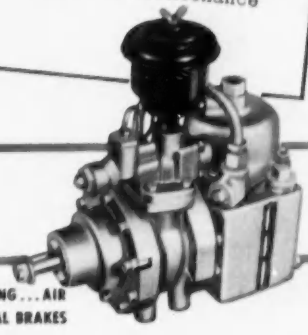

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Rohr has won fame for becoming the world's largest producer of ready-to-install power packages for airplanes – like the Lockheed Constellation, Douglas DC-7, the all-jet Boeing B-52 and other great military and commercial planes.

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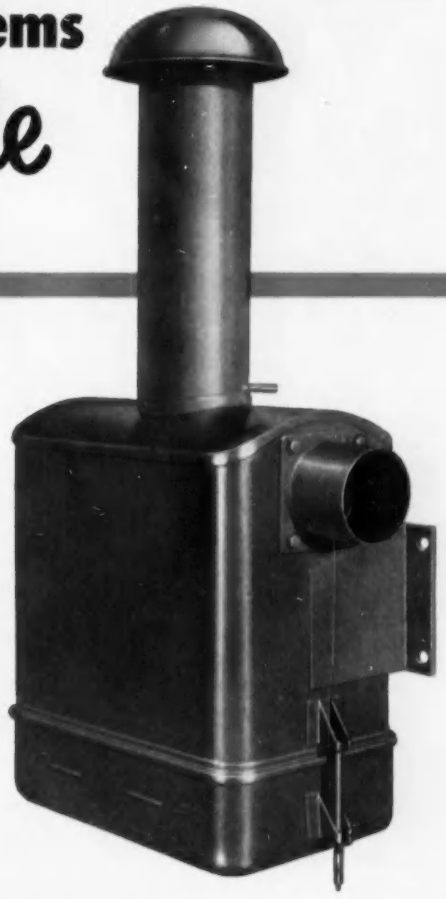
United Takes Unusual Air Cleaner Design Problems *in stride*

United Specialties Company likes to tackle the "problem" air cleaners — those which cannot be easily adapted from the more than 250 standard designs which United engineers have developed. Here are two outstanding examples:



RECTANGULAR CLEANER

This diesel oil bath air cleaner is designed to overcome crowded under-the-hood conditions. Its rectangular shape permits it to fit neatly into available space — provides more room for other accessories. It is available for truck and tractor engines, and for industrial power units.

DUAL CARBURETOR CLEANER

This oil bath air cleaner, designed for use with dual carburetor, has a fixed fitting for one intake and an eccentric fitting for the other. This compensates for any tolerance variations — provides a perfect air cleaner connection to both of the carburetors.

• • •

United Specialties Company builds a complete range of air cleaners for every type of internal combustion engine. Special problems receive special attention from our design engineers. We invite your inquiry.

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Air Cleaners · Metal Stampings · Rolled Shapes · Ignition Switches · Turn Signal Switches · Dovetails

HOW R/M ENGINEERING SETS

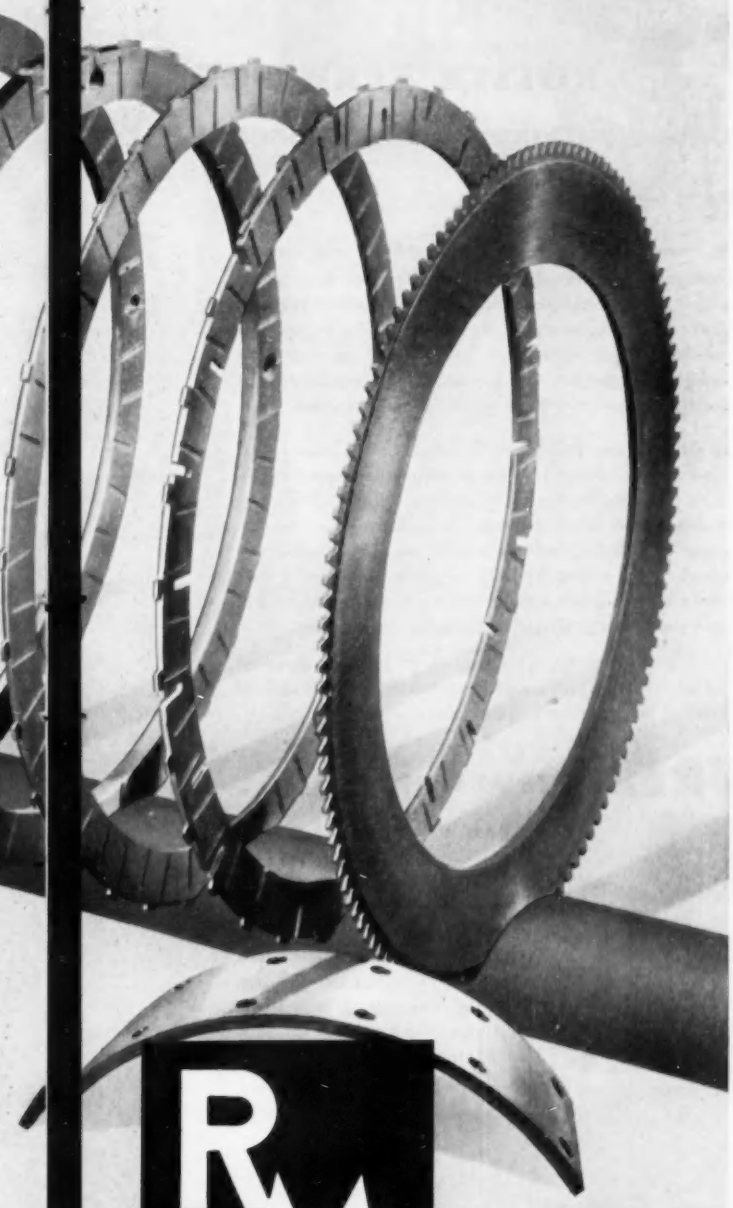
R/M
FIRST IN FRICTION

The sintered metal clutch facings, discs, brake linings and other friction parts pictured here suggest the wide variety of sizes and types that Raybestos-Manhattan, for over 50 years the world's largest maker of friction materials, is manufacturing for specialized applications. The exclusive, patented "metallo-ceramic" bond used by R/M in sintered metal friction materials produces a compound distinctly superior to the common straight alloy bond of copper and tin.

THE RECORD OF "FIRSTS" IN FRICTION MATERIAL DEVELOPMENT SHOWS WHY R/M IS FIRST IN FRICTION

FIRST Woven Brake Lining • FIRST Asbestos Brake Lining • FIRST Ground Wearing Surface • FIRST Zinc Alloy Wire Brake Lining • FIRST Pre-Treated Yarns • FIRST Extruded Pulp Brake Lining • FIRST Flexible Pulp Brake Lining in Rolls • FIRST Dry Process Brake Lining • FIRST Semi-Metallic Brake Lining • FIRST Bonded-to-Metal Brake Lining • FIRST Woven Clutch Facings • FIRST Molded Asbestos Clutch Facings for Clutches Operating in Oil FIRST Endless Woven Clutch Facings • FIRST Pre-Treated Clutch Facings • FIRST Bonded-to-Metal Clutch Facings

THE PACE IN FRICTION MATERIAL DEVELOPMENT



SINTERED METALS

Do you have a friction material application where high temperatures and close tolerances are factors? Or where friction components must be held to a minimum thickness? If so, Raybestos-Manhattan Sintered Metal friction parts may be an exact answer to your problem.

R/M full sintered friction materials are best described as matrices of sintered metal mechanically entrapping both metallic and non-metallic friction-augmenting agents.

Speaking generally, they are most useful where K.E. absorption per square inch of friction material is very high. Or where engagements occur on a repetitive cycle with little time interval. Under such severe conditions, organic-content materials wear at an accelerated rate. R/M Sintered Metals will perform without appreciable increase in wear rate because of their high thermal conductivity and the absence of a destructible bond.

The work done and heat generated by friction material are a function of the pressure involved. A reasonable working range for asbestos materials in dry operation is 25-100 psi. With sintered metal friction material you may go as high as 400 psi.

R/M Sets the Pace in Both the Metal and Asbestos Fields

Raybestos-Manhattan Sintered Metal compounds are designed to meet a distinct and special group of application requirements. They are intended to *supplement* asbestos molded and woven lines—not replace them.

That is why R/M—the leader in both the asbestos and metal fields—is in a unique position to help original equipment manufacturers. Unlike other makers in its field, R/M works with all kinds of friction materials—from woven and molded asbestos to cork-cellulose, semi-metallic, and sintered metals. When you consult an R/M engineer, you can be sure of a *completely unbiased recommendation* as to which friction materials are best suited for your particular application.

If you are looking for friction materials with greater output and durability, call in your R/M representative. The full depth and breadth of R/M experience—the complete facilities of R/M's seven great plants with their research and testing laboratories—are at your disposal to either develop a special material for your requirements or suggest how you can redesign to make effective use of an R/M material already on hand.

Write for your free copy of R/M Bulletin No. 500. Its 44 pages are loaded with practical design and engineering data on all R/M friction materials.

R/M
FIRST IN FRICTION

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ROLLWAY Tru-Rol ROLLER BEARINGS

. . . up-to-the-minute design . . . plus economy

● **Proved in performance . . . proved for economy . . . unsurpassed for versatility . . .** the Tru-Rol Bearing incorporates all the design features accumulated through Rollway's many years of experience in the automotive industry. Long experience has resulted in Tru-Rol's superior adaptability for any application requiring just the right balance between precision and economy.

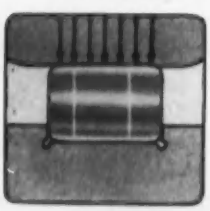
● **Designed for Versatility:** Tru-Rol is available in all the inner and outer race combinations demanded by today's automotive design. Crowned cylindrical rollers eliminate end loading—assure a uniform stress pattern along the *full length* of each roller, and prolong bearing life. Tru-Rol versatility offers a choice of stamped steel retainers with *guide lips*, or steel segmented retainers . . . both providing perfect alignment for every roller.

These features have been quick to gain the favor of automotive engineers, and have led to the selection of Tru-Rol Bearings for a broad variety of applications.

Tru-Rol "Grew-Up" in the Automotive Industry

Rollway's experience in the automotive field dates back to 1927, with the introduction and wide acceptance of a self-contained type of cylindrical roller bearing. 1930 marked the development of the R. B. Bearing, a metric, steel-cage series. The R. B. type was the forerunner of the modern Tru-Rol Bearing.

All Tru-Rol Bearings Now Have CROWNED ROLLERS . . .



Crowned Roller under full load — stress uniformly distributed.

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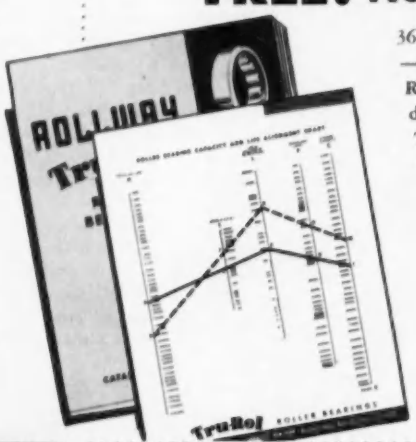

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K Series K2R Series	Maximum Torque Inch Pounds Continuous Load	Hand Operation
K-1-C	350	2,000
K-2-A	350	5,000
L6S Series L6N Series	400	2,000

	Recommended Torque Rating, Inch Pounds Needle Bearings	Optional
L10S Series	650	"
1FR Series	1,080	"
L14S Series	1,230	"
3DR Series	1,800	"
L16S Series	2,200	"
L12N Series	3,300	"
L14N Series	6,000	"
35N Series	10,000	"

N Series	Recommended Torque Rating, Inch Pounds	Balanced for
45N	14,000	3600 R.P.M. Max
5N	20,000	"
50N	20,000	"
6N	38,000	"
60N	38,000	"
7N	57,000	"
70N	57,000	"
75N	70,000	"

BW Series	Maximum Torque Inch Pounds Continuous Load	Momentary Load
BW-12	1,020	4,450
BW-1	1,695	7,500
BW-2	3,350	11,720
BW-3	4,450	16,800
BW-4	5,080	22,900
BW-5	8,640	34,200
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*Extra shock-load capacity built into all sizes.

Need a moderately small universal joint on your next project — for a hand-operated control rod, for example? Blood Brothers has it! In fact, you can select from any of four Series — all widely used on farm implements, road and construction machinery, tractor steering assemblies, etc.

Or do you need a source for high speed joints and propeller shaft assemblies for trucks, busses or other mobile equipment? Blood Brothers builds a wide selection of automotive assemblies with torque capacities to 70,000 inch pounds.

For really heavy work, look at the BW Series — for transmitting up to 1,400 H.P. with momentary loads reaching 500,000 torque inch pounds! It's the largest commercial universal joint made — and Blood Brothers makes it.

Thus, when you specify Blood Brothers, you can select from a wide range of torque capacities . . . and be confident of top-quality universals that contribute dependability and smoothness to your product's performance.

For details, contact Blood Brothers, stating your specific problem. We'll be glad to cooperate with engineering suggestions.

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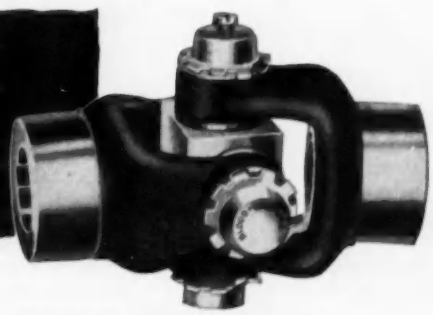

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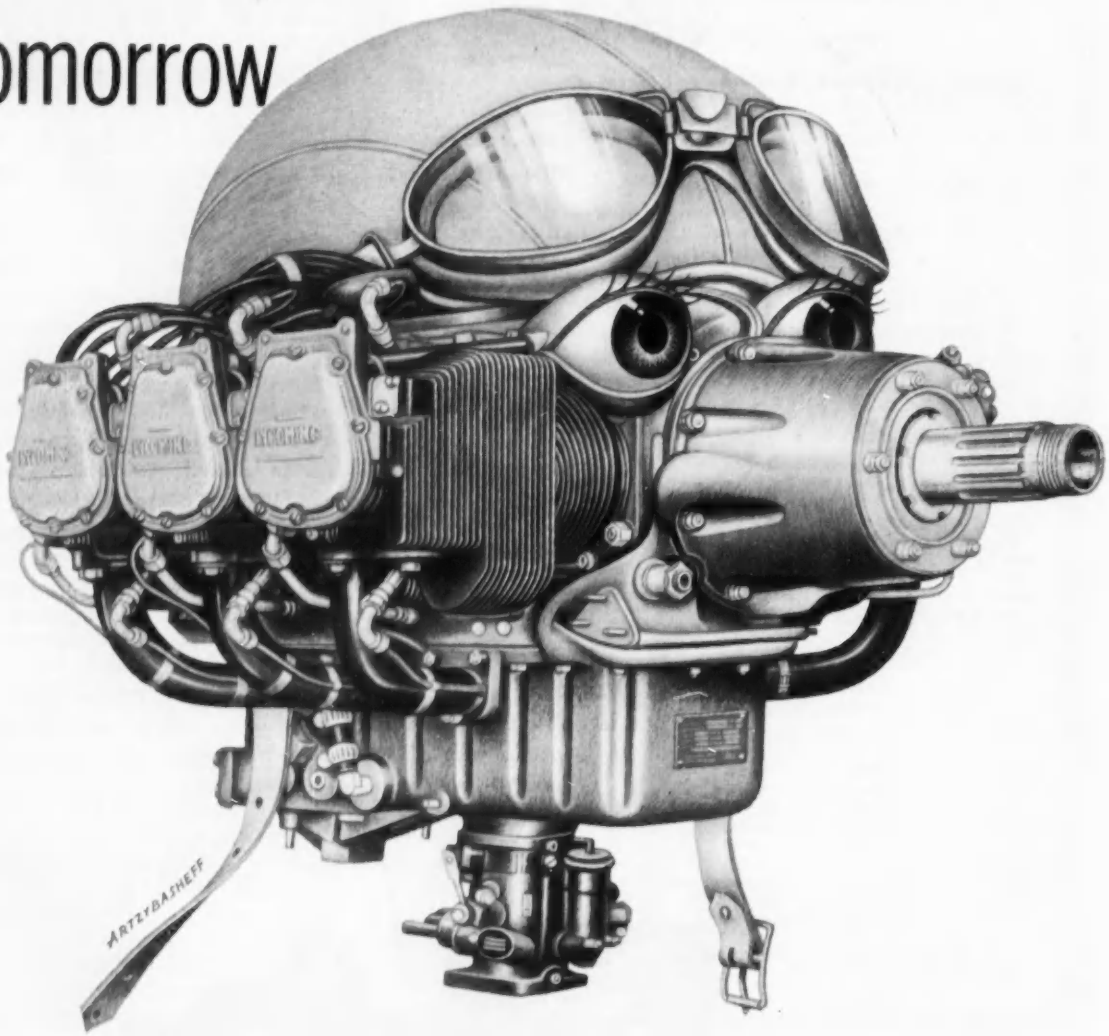
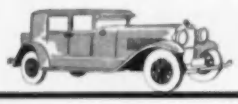
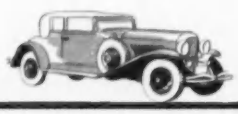


DORT—1915



AUBURN—1924



DUSENBERG—1929

Not long after the start of this exciting century, Lycoming powered some fondly remembered automobiles. At one point in the "roaring twenties," Lycoming-built power plants were roaming in twenty-five of that era's proudest models.

"He's" a typical Lycoming engine—with an illustrious past and a vital future. First an automobile "daredevil," then a modern aviator, he now powers more different types of aircraft than any other engine in the world. Tomorrow, whether equipped with pistons or turbine rotors, he'll be working harder than ever to keep America moving.

Lycoming engines have had a full and glorious history. They kicked up dust in some grand old automobiles . . . threshed in the famous John Deere combine . . . used their muscles in World War II for trainers, 'copters, liaison planes.

Today, they're the mainstay of a huge "business plane" fleet. You can hear the "hum" of Lycoming engines in more different types of fixed and rotary wing aircraft than any other engines in the world.

Do you need this kind of rugged, proven power? Will *turbine* power solve some of your current or future problems? Right now, Lycoming is developing improved gas turbines for the U. S. Air Force. For dependable power plants—reciprocating or turbine—*look to Lycoming!*

Lycoming's wealth of creative engineering ability . . . its 2½ million square feet of floor space and 6,000-plus machine tools stand ready to serve you. *Whatever* your problem . . . *look to Lycoming!*

Aircraft Engines
Industrial and Tank Engines
Engine Overhaul
Generating Units

Turbine Engineering and Research
Engineering Design and Development
Hardened and Ground Precision Parts
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Complete Assemblies
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Steel Fabrication
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FOR RESEARCH • FOR PRECISION PRODUCTION

LOOK TO **Lycoming**

DIVISION OF AVCO STRATFORD, CONN.
Manufacturing plants in Stratford, Conn., and Williamsport, Pa.

STINSON MODEL A—1931 STEARMAN TRAINER—WORLD WAR II PIPER APACHE—1954

The next decade saw Lycoming engines keeping some of the earliest scheduled airliners "upstairs." Today, they put the "purr" in 55 different types of aircraft—more than any other engines in the world.

Wheel engineering at its best

Our industrial world started with the wheel.

Little known to most people, but highly regarded among engineers, the science of wheel engineering has reached its most advanced stage of development at Kelsey-Hayes. Here, with a background of experience that goes back to the birth of the automobile, specialists in wheel engineering design, test and build wheels, hubs and drums for almost every kind of vehicle.

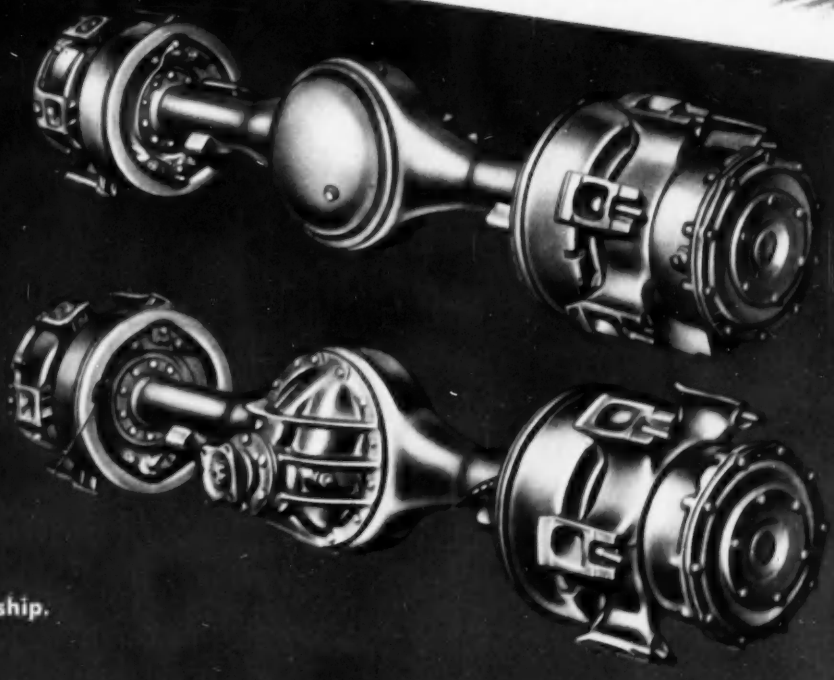
Because this pioneering development work goes on all the time most leading manufacturers of modern passenger and commercial vehicles look to Kelsey-Hayes for leadership in wheels.
Kelsey-Hayes Wheel Company, Detroit 32, Michigan.

KELSEY HAYES

World's Largest Producer of Automotive Wheels

Wheels, Brakes, Brake Drums, Special Parts for all Industry • 9 Plants—Detroit and Jackson, Mich. . . . McKeesport, Pa. . . . Los Angeles . . . Windsor, Ont., Canada . . . Davenport, Ia. (French & Hecht Farm Implement and Wheel Div.)

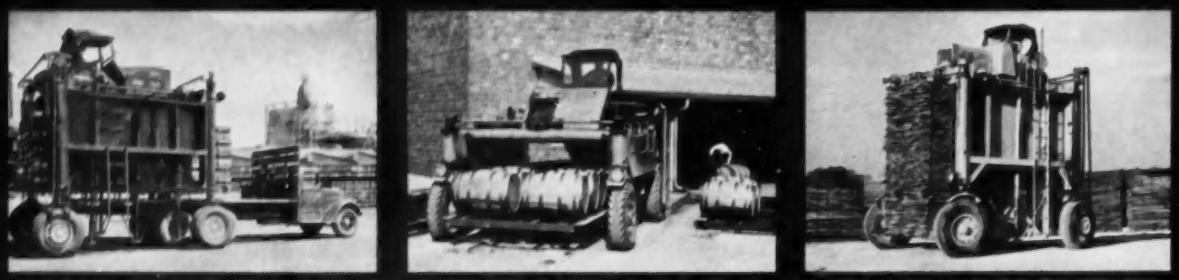
Veteran "Work Horses"



Seasoned operators of "revenue" equipment have always recognized Clark Driving Axles as "having what it takes"—in rugged strength, simplicity of design, excellence of workmanship. They're right about it.

CLARK EQUIPMENT COMPANY • BUCHANAN • Battle Creek, Jackson and Benton Harbor, Michigan

CLARK® EQUIPMENT



One man loads it . . . in 5 seconds, up to 50,000 lbs. . . .

One man drives it . . . speeds up to 56 mph

One man unloads it . . . in 3 seconds

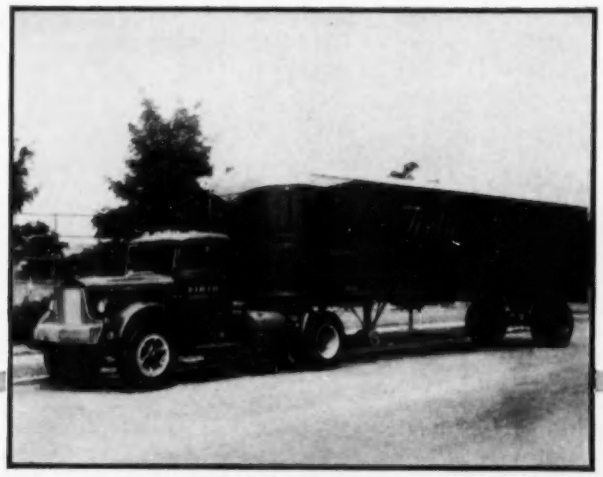
Free 25-minute sound movie starring the **ROSS CARRIER**

"Over-the-Load Materials Handling"

You can revolutionize your handling operations! You can move materials faster, farther, at less cost, and this new movie shows you how to do it. As in the above pictures from the film, you'll see the Ross Carrier handling pineapples, whiskey barrels, lumber packages, heat exchangers, cotton bales, steel tube—for aggressive, cost-conscious companies which have discovered the unique advantages of over-the-load handling. If you are sincerely interested in knowing what's new in materials handling, you won't miss this free movie. It's available on a loan basis. We'll mail the film to you—your only cost is return postage.

CLARK EQUIPMENT

ROSS CARRIER DIVISION, CLARK EQUIPMENT COMPANY, Benton Harbor, Michigan



Keeping downtime to a minimum is a must for heavy duty truckers. That's why so many choose Lipe Clutches.

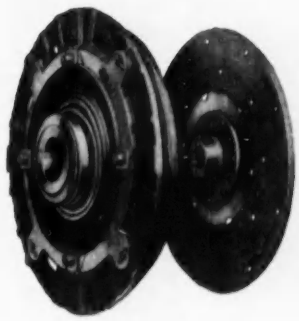
MORE ENGAGEMENTS BETWEEN TEARDOWNS

NO SHOCK! NO GRAB!
NO COCKED PLATES!

LIPE *MULTI-LEVER HEAVY DUTY* CLUTCH

The Lipe *multi-lever* Clutch *gives more engagements between teardowns.* There's no grab, no shock. Strain on engine and drive-line is reduced, tire mileage increased.

Here's the reason: *There's only one spring.* Spring pressure is distributed uniformly around the full 360° perimeter of the pressure plate by 20 pressure-equalizing levers. Every part of the pressure plate touches at the Same Instant . . . with the Same Pressure. *There's no cocking of the plate.* No areas of high-speed slippage and localized burning. Circulated air keeps internal temperatures low. The clutch engages smoothly . . . requires no babying . . . holds without slippage in final engagement . . . disengages with light pedal pressure.



FLEET OWNERS

Fast, easy adjustment assures torque capacity for the full life of the friction material. No special tools required. Quick service on parts. Write for complete data on genuine Lipe parts stocked in principal cities.

LIPE ROLLWAY

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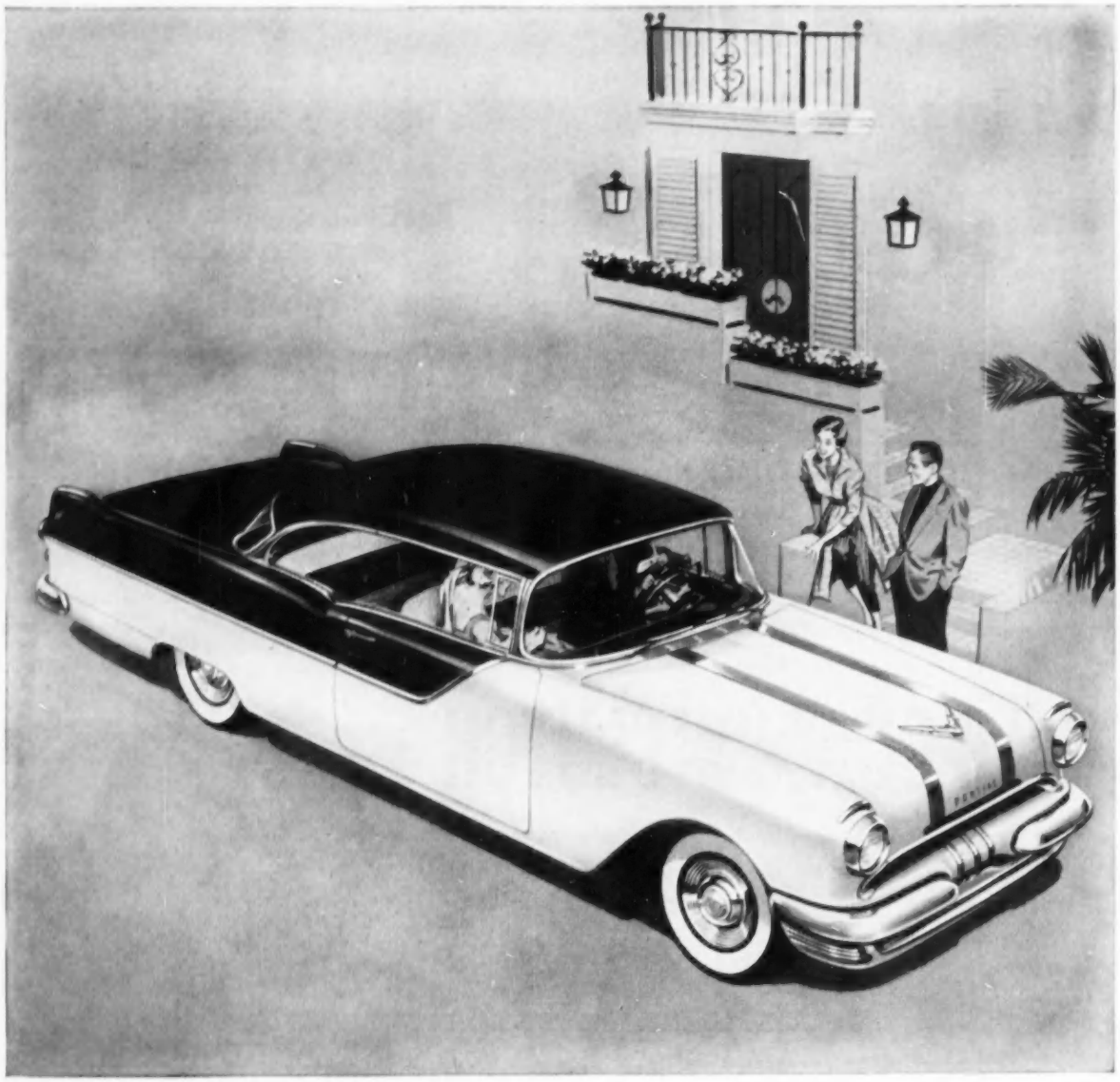
Manufacturers of Automotive Clutches and Machine Tools

Syracuse 1, N. Y.



Take the Wheel—and Overtake Tomorrow!

Some day other cars may attain the cleancut distinction of Pontiac styling or the clearcut advantages of Pontiac's Strato-Streak V-8 performance. *But not now!* Today, these car-of-tomorrow features are Pontiac exclusives—visual and thrilling evidence of the long way Pontiac has gone to bring you a joyously new kind of motoring. Just how delightfully different Pontiac ownership can be we invite you to prove by piloting a Pontiac on a route of your choosing. And don't be afraid to lose your heart! This future-fashioned General Motors masterpiece is tagged with a wonderfully pleasant price. Confirm today the many reasons why it's Pontiac's year to star!

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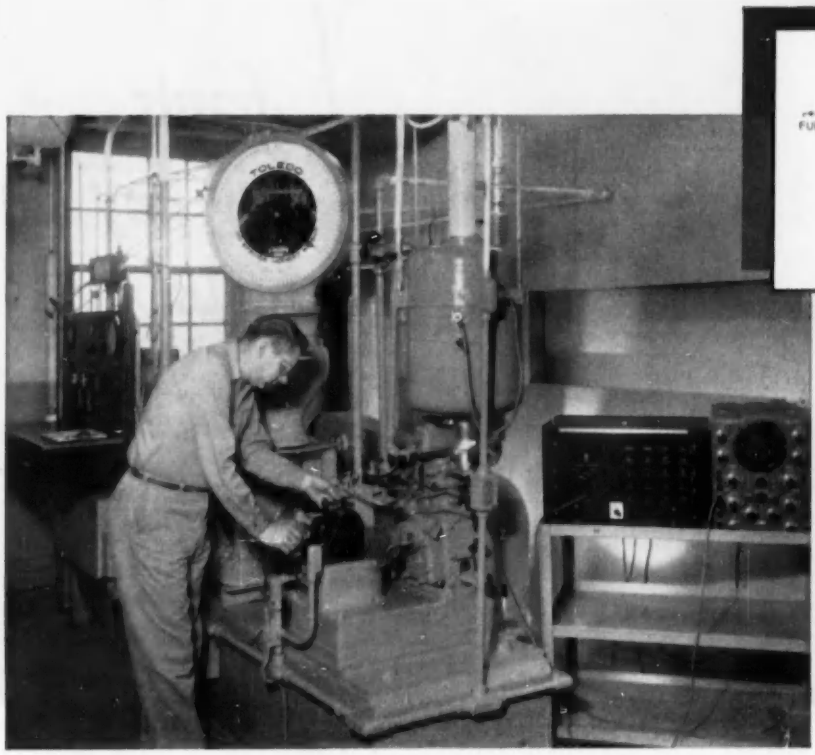
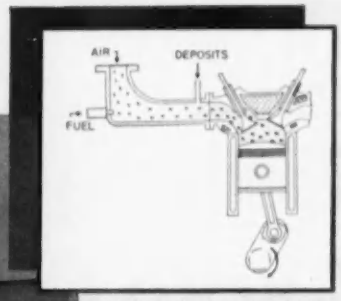
'55 Pontiac

WITH THE SENSATIONAL STRATO-STREAK V-8

PONTIAC MOTOR DIVISION OF GENERAL MOTORS CORPORATION





▲ Schematic diagram of unusual "Dust-Injection" engine. Engine operates under typical non-knocking conditions to isolate chemical reactions associated with surface ignition.

◀ A modified C. O. T. Engine and an Electronic Counter are the apparatus used in the "aspirated deposit surface ignition test" at the Du Pont Petroleum Laboratory. Engineers create controlled surface ignition by introducing a small quantity, usually 0.1 g or 0.5 g, of powdered combustion-chamber deposit into the intake port.

Unique *Dust-Injection engine* for studying surface ignition at the Du Pont Petroleum Laboratory

By increasing the compression ratio of an engine you increase the engine's fuel utilization efficiency. However, with present fuels you're faced with the engine's increased tendency toward surface ignition.

For many years, Du Pont has been pioneering the study of engine deposits and their contribution to knock and surface ignition.

Pin-pointing ping

In order to study the erratic process of surface ignition under controlled conditions, engineers at the Du Pont Petroleum Laboratory developed a novel test, called the "aspirated deposit surface ignition test." The technique uses a single-cylinder engine, modified to permit the introduction into the intake port of a small amount of powdered combustion-chamber deposit.

The dust-injection engine uses a fuel susceptible to surface ignition, containing benzene or diisobutylene. The number of surface ignitions caused by the introduction of the combustion-chamber "dust" is taken as the measure of surface ignition harm of deposits.

An internal type of pickup, mounted in the engine cylinder, detects surface ignition. The number of surface ignitions is counted by a four-decade counting unit actuated by a signal from the pickup.

Progress Report

The "dust injection" test is one of many projects comprising Du Pont's fundamental approach to assist the automotive industry in overcoming surface ignition.

Findings from this unique test method reveal the relationship between the composition of combustion-chamber deposits and their contribution to surface ignition. This knowledge suggests leads to new additives with the ability to overcome the harmful action of these residues.

A technical paper, "Pre-Ignition in Automotive Engines," discusses in detail the Du Pont work on this problem. Write us if you would like to have a copy.

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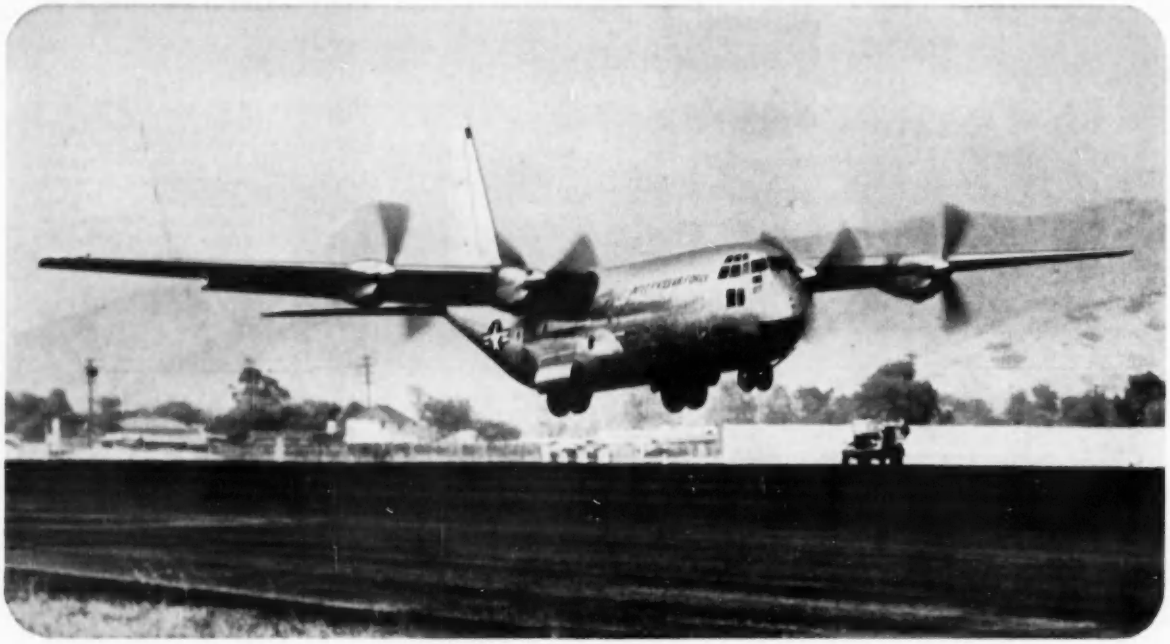
New Turbine-Powered Cargo Carrier

hauls big pay loads faster



Allison T56 Turbo-Prop Engines Power New Lockheed YC-130 Transport

The initial flight of the YC-130 Medium Cargo Transport marks another great forward stride in transport aviation.

This giant carrier, built by Lockheed for the U. S. Air Force, is the first U. S. A. F. cargo plane designed from the very beginning for Turbo-Prop engines.

Powered by four of the new Allison T56 Turbo-Prop engines, this great new cargo airplane can haul heavy pay loads long distances at speeds required by our new modern combat jet Air Force. It is ideally suited to carry many types of heavy military equipment, on either long-range operations or in close support of troops. It also can be fitted as a combat troop carrier or an ambulance plane. The YC-130 can operate from shorter runways with greater rate of climb than either reciprocating or Turbo-Jet engine aircraft.

All this, plus its economical use of lower cost fuel, label the Turbo-Prop engine as the "work horse" power for future transports. And Allison, with its unmatched experience in high-powered Turbo-Prop design and manufacture, today offers both T56 and T40 engines to serve a broad range of modern flight requirements.

GM GENERAL MOTORS Allison Division of General Motors, Indianapolis, Indiana

In 1905

IMPERIAL

INTRODUCED THE FIRST TUBE FITTINGS TO INDUSTRY

. . . this was the beginning of 50 years of pioneering leadership in tubing connection practice

50th Anniversary IMPERIAL 1905-1955

The history of Tube Fittings and Tube Working Tools is written in important measure in the history of The Imperial Brass Mfg. Co.

For in 1905, when automobiles were in their infancy and industry was just beginning an era of vigorous progress, Imperial introduced the first flare fittings, and then the first compression fittings—the forerunners of practically all modern tube fittings.

Since that time IMPERIAL has remained in the forefront in the development of tube fittings, shut-off valves and tubing tools—a pioneering leadership that has resulted in easier, faster and better methods of connecting, valving and working with tubing.

IMPERIAL also manufactures a host of other products for industry. Each carries the Diamond "I", the Emblem of Quality.

THE IMPERIAL BRASS MANUFACTURING COMPANY, 1225 W. Harrison Street, Chicago 7, Illinois

IMPERIAL

Pioneers in Tube Fittings and Tube Working Tools

Emblem of Quality

Auto-Lite is world famous for long life, performance and economy

Around the world, more than 400 products of Auto-Lite are used day and night in cars, trucks, planes, boats and industry . . . convincing proof of the outstanding quality made possible by Auto-Lite advanced engineering and precision manufacturing. So to get the best in long life, in power and performance and in economy, it pays to insist on world famous Auto-Lite products.

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WINDSHIELD WIPERS • WINDOW LIFTS • SEAT MOVING MECHANISMS • HUB CAPS
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THE ELECTRIC AUTO-LITE COMPANY • TOLEDO 1, OHIO

"The automotive industry knows but one way to go— and that's ahead"!

Roy C. Ingersoll

President

BORG-WARNER CORPORATION

Borg-Warner

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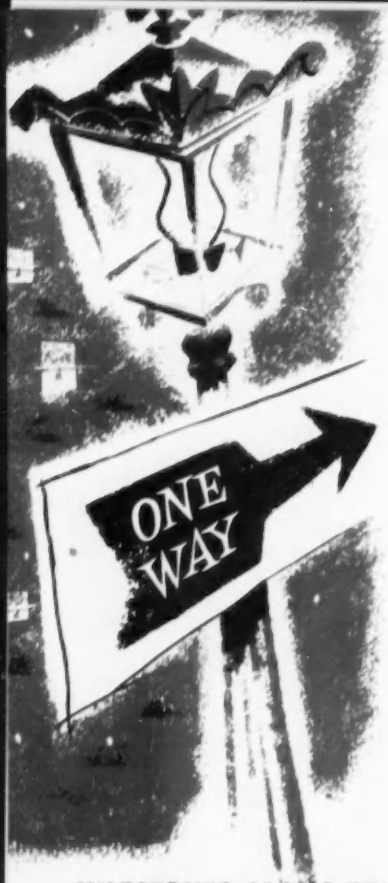


one way...

ahead

The history of the automotive industry is one of dynamic and continuing progress. Since the days of the "horseless carriage" each year's new models have been marked with exciting advancements in design, engineering, production and performance.

Yet the accomplishments of the past are simply a promise of future achievement . . . because the automotive industry knows but one way to go—and that's ahead.

Borg-Warner is proud of its part in the industry's growth . . . proud of its contributions to automotive safety, performance, economy and value through creative engineering and volume production of essential parts.

"Design it better—make it better" is the guiding principle of Borg-Warner. It is at once our challenge, and our pledge to the automotive industry.

Roy D. Ingersoll

President

BORG-WARNER CORPORATION

MILESTONES ALONG THE WAY

1900—The old time mixing valve was replaced by SCHEBLER carburetors.

1903—Radiators made of copper tubing with attached cooling fins introduced by LONG.

1913—The single plate clutch was developed by BORG & BECK, and silent timing chains were introduced by MORSE CHAIN.

1916—Universal joints were developed by MECHANICS.

1921—First standard type transmissions were introduced by WARNER GEAR.

1922—Double plate clutches were introduced by LONG.

1923—Multiple spring clutches were developed by ROCKFORD.

1924—Vibration dampening flexible center clutches introduced by BORG & BECK.

1930—Transmission synchronizer units produced by WARNER GEAR.

1931—Free wheeling was introduced to the industry by WARNER GEAR.

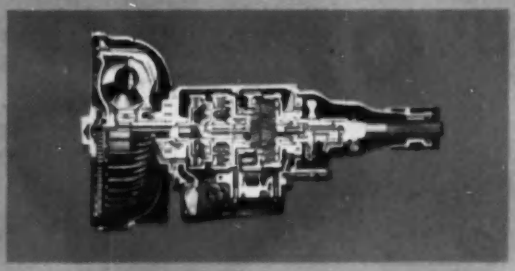
1934—Automatic overdrives for transmissions were introduced by WARNER GEAR.

1938—Borglite and Torbend clutch plates were introduced by BORG & BECK, LONG and ROCKFORD.

1949—Simpler, finer, more efficient automatic transmissions were introduced by DETROIT GEAR and WARNER GEAR.

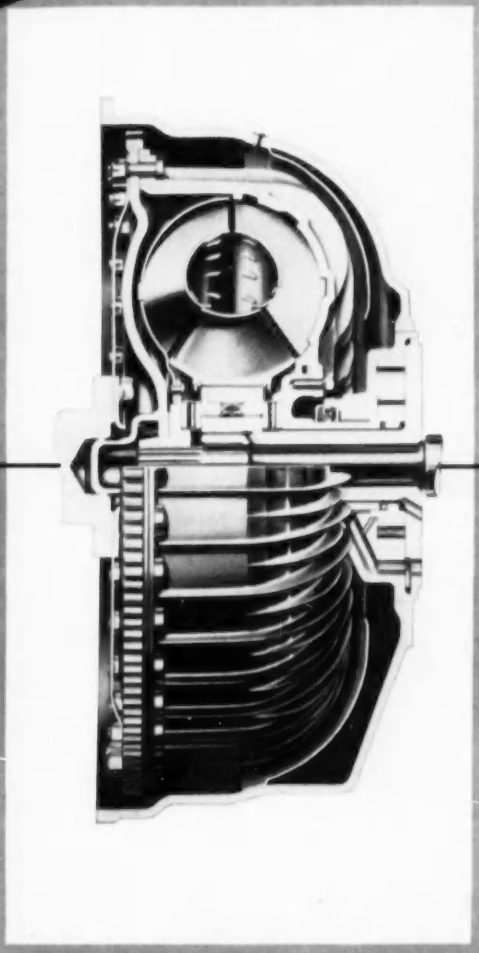
1952—LP-Gas carburetion systems developed by MARVEL-SCHEBLER.

1953—Passenger car power brakes developed by MARVEL-SCHEBLER.



the new
BORG & BECK TORQUE CONVERTER

used in Fordomatic and Merc-O-Matic transmissions



An air-cooled Torque Converter of unique design with steel blades assembled in die-cast aluminum Impeller whose 68 fins provide swift cooling.

The Turbine is made of steel stampings and the Stator is aluminum. Its One-Way 20 sprag clutch is Borg-Warner's well-proved design.

Light in weight, with a torque ratio of 2.1:1, it has excellent efficiency, yet it can be readily disassembled in the field for inspection or repair.

BORG & BECK CLUTCH · THE STANDARD ·

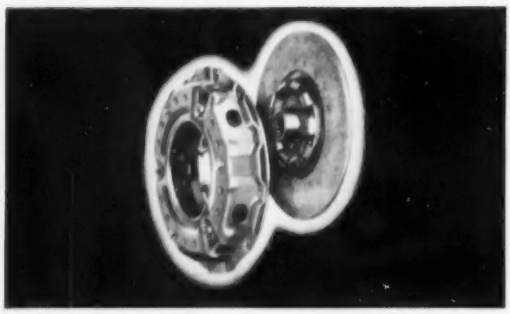
BORG & BECK DIVISION

BORG - WARNER CORPORATION

Chicago 38, Illinois

ENGINEERING B-W PRODUCTION

CLUTCH KNOW-HOW AT YOUR SERVICE



ROCKFORD CLUTCH engineers have designed clutches, power take-offs and speed reducers for hundreds of different products. This wide experience can help solve your power transmission control problems. Just send a description or print of your needs for their recommendations.

SEND FOR THIS HANDY BULLETIN

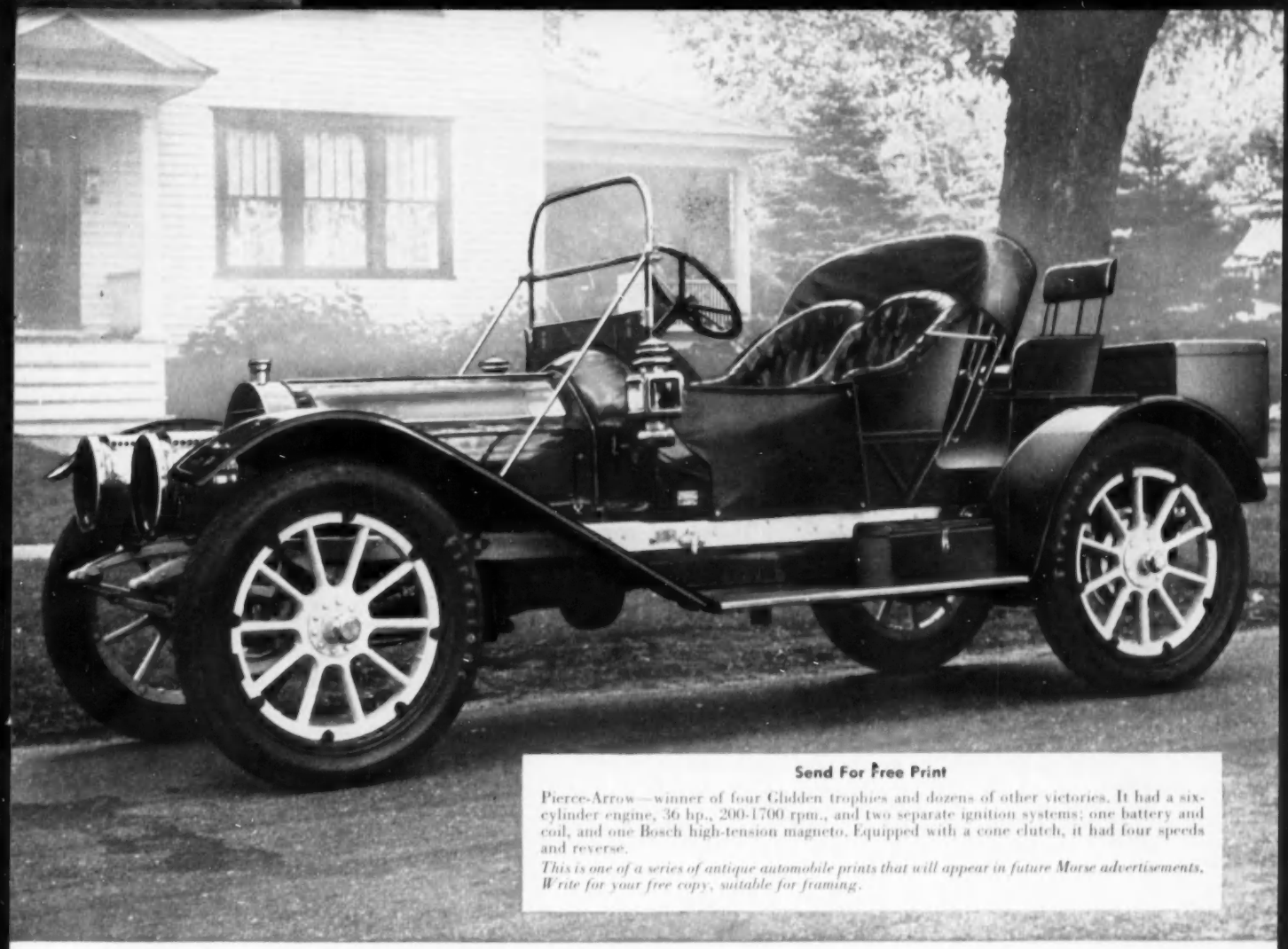
Shows unique ROCKFORD CLUTCH and POWER TAKE-OFF applications. Contains diagrams, dimensions, capacity tables, etc.

ROCKFORD CLUTCH DIVISION

Borg-Warner Corporation

316 Catherine Street, Rockford, Illinois

ROCKFORD CLUTCHES



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Pierce-Arrow—winner of four Glidden trophies and dozens of other victories. It had a six-cylinder engine, 36 hp., 200-1700 rpm., and two separate ignition systems; one battery and coil, and one Bosch high-tension magneto. Equipped with a cone clutch, it had four speeds and reverse.

This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free copy, suitable for framing.

Have you used any of our 58,000,000 timing chain drives?

If you use Morse Timing Chain Drives, you know all about their economy, long service life, and relative freedom from maintenance.

If not, it may pay you handsomely to consider them as original equipment for your cars, trucks or buses. More than 58,000,000 of these drives have been installed in cars and trucks of over 100 different makes.

Whether your engines are in the design, development or application stages, Morse engineering service is available to help you solve your timing chain problems. Call or write us, today.

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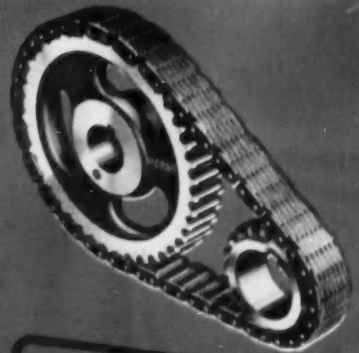

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Morse *means* Timing Chains

LONG TORQUE CONVERTERS ARE *CUSTOM-ENGINEERED* FOR EVERY JOB

NOW—for the first time—LONG Manufacturing Division of B-W offers *one complete package* tailored to fit *your* power transmission requirements.

Engineered and manufactured entirely by B-W, the LONG package includes the *right* converter for *your* power plant . . . the *right* clutches, gearboxes, pumps, heat exchangers, bell housings, universal joints and accessory equipment.

Available in a wide range of power ratings for . . .

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Cranes • Dirt pushers • Lumbering equipment • Ore and oil well devices • Road rollers • Shovels, Track-laying vehicles • Lift trucks • Self-propelled machines

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Tractors • Balers • Combines • Pickers • Loaders • Diggers • Cutters • Well-drillers • Bulldozers and countless new agricultural machines

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Auxiliary engine-room power plants • Dockside cranes • Winches • Cargo-handling equipment • Davits • Pumps • Anchor-chain capstans • All variable-load machinery

LONG MANUFACTURING DIVISION • BORG-WARNER CORP. • DETROIT, MICH. AND WINDSOR, ONT.

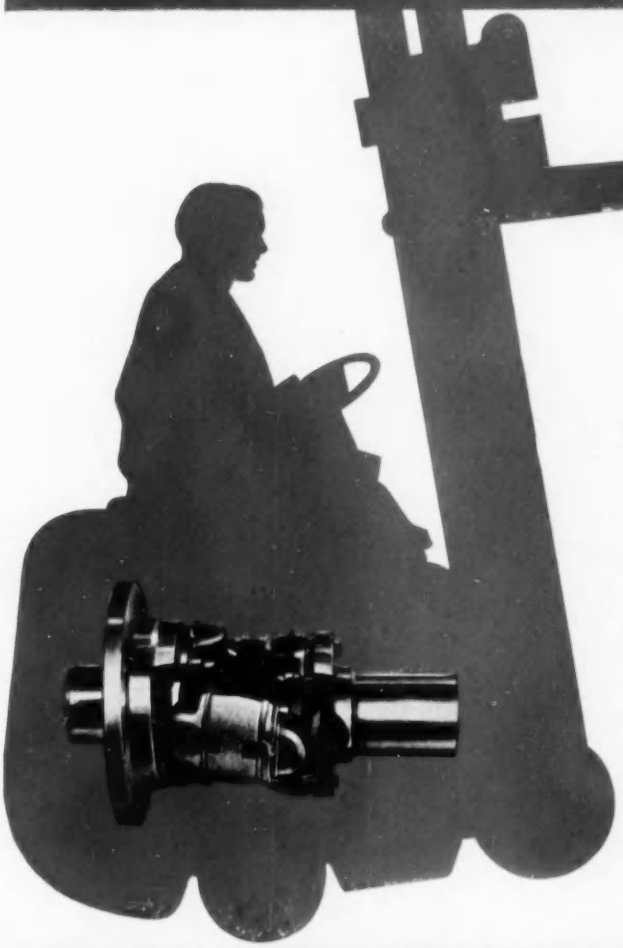
50 Years
of Quality Manufacturing for the Automotive Industry

LONG

A PRODUCT OF BW BORG-WARNER

TORQUE CONVERTERS • CLUTCHES • RADIATORS • OIL COOLERS

VERSATILE



MECHANICS Roller Bearing UNIVERSAL JOINTS excell for both main drives and controls — in all kinds of material handling trucks. Have transmission flanges for any type of brake drum. Easy to service — MECHANICS Close-Coupled UNIVERSAL JOINTS transmit more power — in less space — at greater angles than any other joints. Let MECHANICS engineers help give *your* machines competitive advantages.

MECHANICS UNIVERSAL JOINT DIVISION
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UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

Built to provide unfailing power for heavy-duty power steering, Pesco Model 052817 Hydraulic Pump weighs only 6.75 pounds, requires little mounting space, operates on minimum power.

Better steering starts here!

Improved power steering for all types of heavy-duty vehicles, both over-the-road and off-the-road units, starts with Pesco's Hydraulic Steering Pump. On trucks, tractors and construction equipment, this Pesco-designed pump provides unfaltering hydraulic power regardless of operating conditions.

This engine-driven, positive-displacement gear pump features: (1) "Pressure loaded" bearings which automatically adjust for wear assuring sustained new pump performance, (2) minimum power requirements, (3) minimum size and weight, (4) self-lubrication by fluid pumped and (5) a standard pressure relief setting of 750 psi. Operating at 750 psi and 750 rpm, it delivers 3.0 gallons per minute.

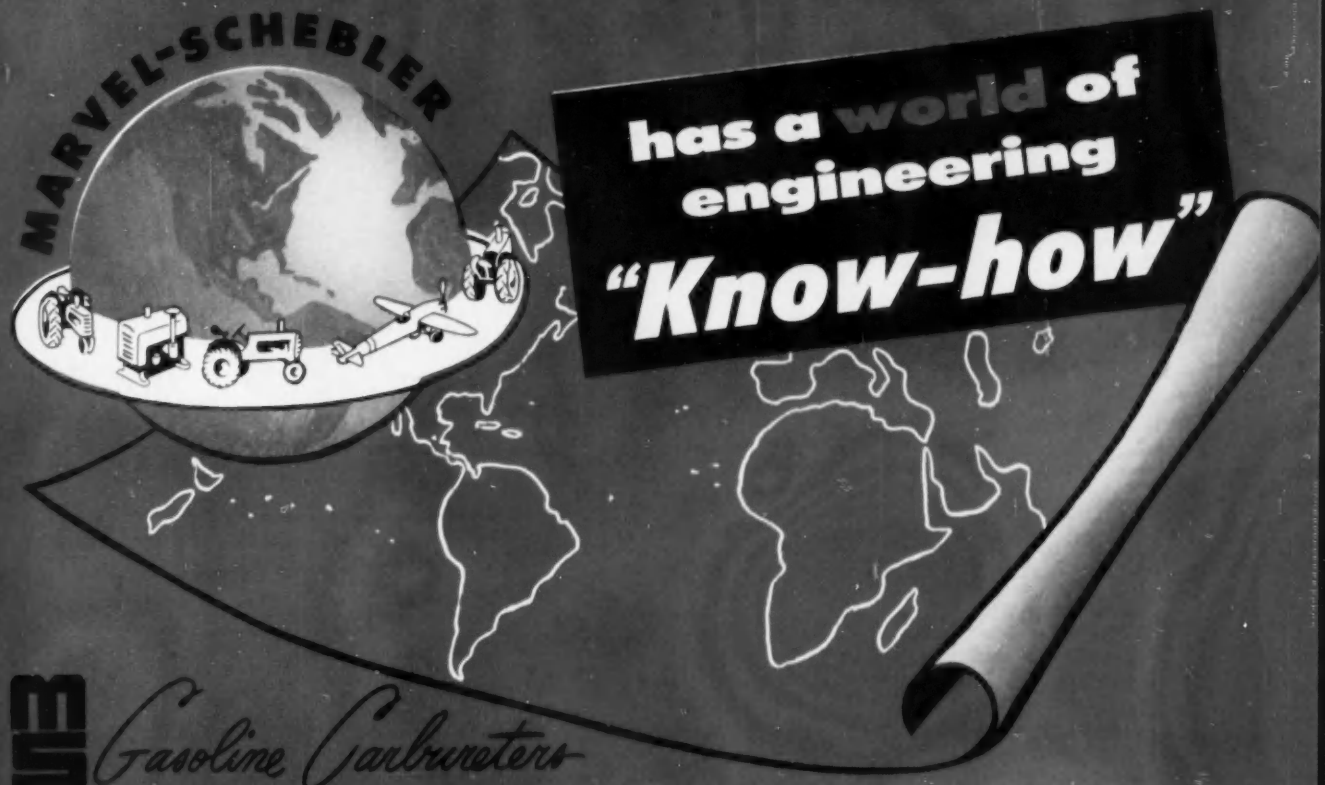
Pesco creative engineering produced this pump—and it can produce a pump designed for your exact needs. The experience and "know-how" of Pesco engineers may produce a better and more profitable answer to your hydraulic power problem. This engineering service is available to you . . . and we think you will like the results you get.

Pesco engineers will be glad to supply complete technical information. Operating models are available for testing on your equipment. Call or write: PESCO, 24700 North Miles Road, Bedford, Ohio.

engineering Pesco production
PRODUCTS DIVISION

AGRICULTURAL · INDUSTRIAL · AIRCRAFT · AUTOMOTIVE · CONSTRUCTION · EARTH MOVING

BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO



has a world of engineering "Know-how"

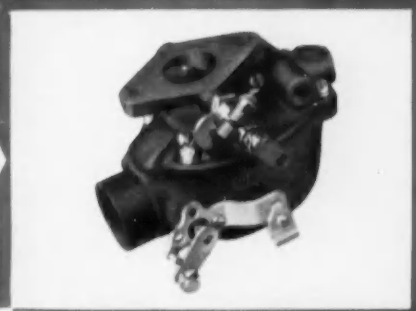
Gasoline Carburetors

especially engineered for Tractor, Aircraft and Industrial Engines

Our customers' demands—representing a wide variety of different industries—have given Marvel-Schebler the "KNOW-HOW" to solve *your* carburetor problems.

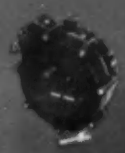
Whatever your particular needs, the finest engineering and production skills, with complete research and design facilities guarantee you full satisfaction when you call on Marvel-Schebler.

Updraft, horizontal and downdraft carburetors for tractors and industrial engines are available with fixed or adjustable power systems in sizes ⅛", ⅞", 1" and 1¼" for engines up to 100 Horsepower.



Aircraft float type updraft carburetors furnished in sizes 1¼", 1½" and 2" for engines from 50 to 250 Horsepower. Features: Cast Aluminum construction, Manual or Automatic Mixture Control, Idle cutoff, Dual floats for angular operation.

• Power Brakes For Passenger Cars and Trucks



• LPG Carburetion Systems For Trucks, Tractors and Industrial Engines

A line of downdraft, updraft and horizontal carburetors for industrial applications in sizes ¾", ⅞" and 1" with fixed or adjustable power systems. Horsepower range 1 to 50, used on lawnmowers, outboards, generators, diesel starting engines and other applications.

MARVEL-SCHEBLER *Products Division*
BORG-WARNER CORPORATION · DECATUR, ILLINOIS

For a completely equipped and expertly staffed research laboratory for power brake, LPG and gasoline carburetor development . . . plus trained engineering fieldmen to assist you . . . call Marvel-Schebler!

21 of the 30 Divisions of Borg-Warner Serve the Automotive Industry

BORG & BECK—clutches and torque converters for passenger cars, trucks and tractors.

BORG-WARNER INTERNATIONAL—export sales of automotive parts.

BORG-WARNER SERVICE PARTS—U. S. distribution of automotive service parts.

CALUMET STEEL—special automobile jack bar steel; small angles for auto seats.

DETROIT GEAR—automatic transmissions for passenger cars and trucks; truck, tractor and bus transmissions; gears and precision parts for passenger cars, trucks, tractors and aircraft.

FRANKLIN STEEL—special automobile jack bar steel; spring steel bumper supports; small angles for auto seats.

INGERSOLL PRODUCTS—tapered steel discs for truck wheels; automotive stampings; bumper and stabilizer bars.

INGERSOLL STEEL—automotive and tractor clutch discs; carbon electric steel for tank clutch plates; high carbon and alloy steel sheets; stainless and stainless-clad sheets and armor plate.

LONG MANUFACTURING—clutches and radiators for passenger cars, trucks, buses and tractors; torque converters; oil coolers for the automotive industry.

LONG MANUFACTURING CO., LTD. (Canada)—Clutches and radiators for passenger cars, trucks, buses and tractors; oil coolers for the automotive industry.

MARBON—adhesives for bonding rubber and synthetic rubber to metal and other materials (trade name Ty-Ply).

MARVEL-SCHEBLER PRODUCTS—carburetors for military and industrial equipment and farm tractors; LPG carburetion systems; power brakes for passenger cars and trucks.

MECHANICS UNIVERSAL JOINT—universal joints and propeller shafts for passenger cars, trucks, buses, aircraft, farm machinery, tractors, road machinery and mining machinery.

MORSE CHAIN—automotive timing chains and sprockets.

MORSE CHAIN CO., LTD. (England)—Automotive timing chains and sprockets.

PESCO PRODUCTS—electric driven and engine driven hydraulic pumps; valves and electric motors for agricultural and industrial use.

ROCKFORD CLUTCH—spring-loaded and over-center clutches for automobiles, trucks, tractors, road-building, earth-moving and oil field machinery, industrial machinery, agricultural implements, machine tools (Pullmore). Power take-off and gear reduction units for gasoline and diesel engines.

SPRING DIVISION—torque converter parts and sub-assemblies; sprag type free wheeling clutches; special clutch plates and parts for automatic transmissions; precision flat and Belleville type springs; automobile clutch and valve springs; multislide and punch press stampings, plain and heat treated; special commercial heat treating; small electric motor commutators.

WARNER AUTOMOTIVE PARTS—for replacement purposes—ring gears and pinions; differential cases; differential internal gears and spiders; axle shafts; cast iron parts; transmission gears for passenger cars, trucks and tractors; power take-offs.

WARNER GEAR—automatic transmissions for passenger cars; standard transmissions for cars, trucks, taxicabs, buses and tractors; overdrive units for passenger cars; transfer transmissions for trucks; synchronizer units for passenger cars and trucks; parking brake assemblies.

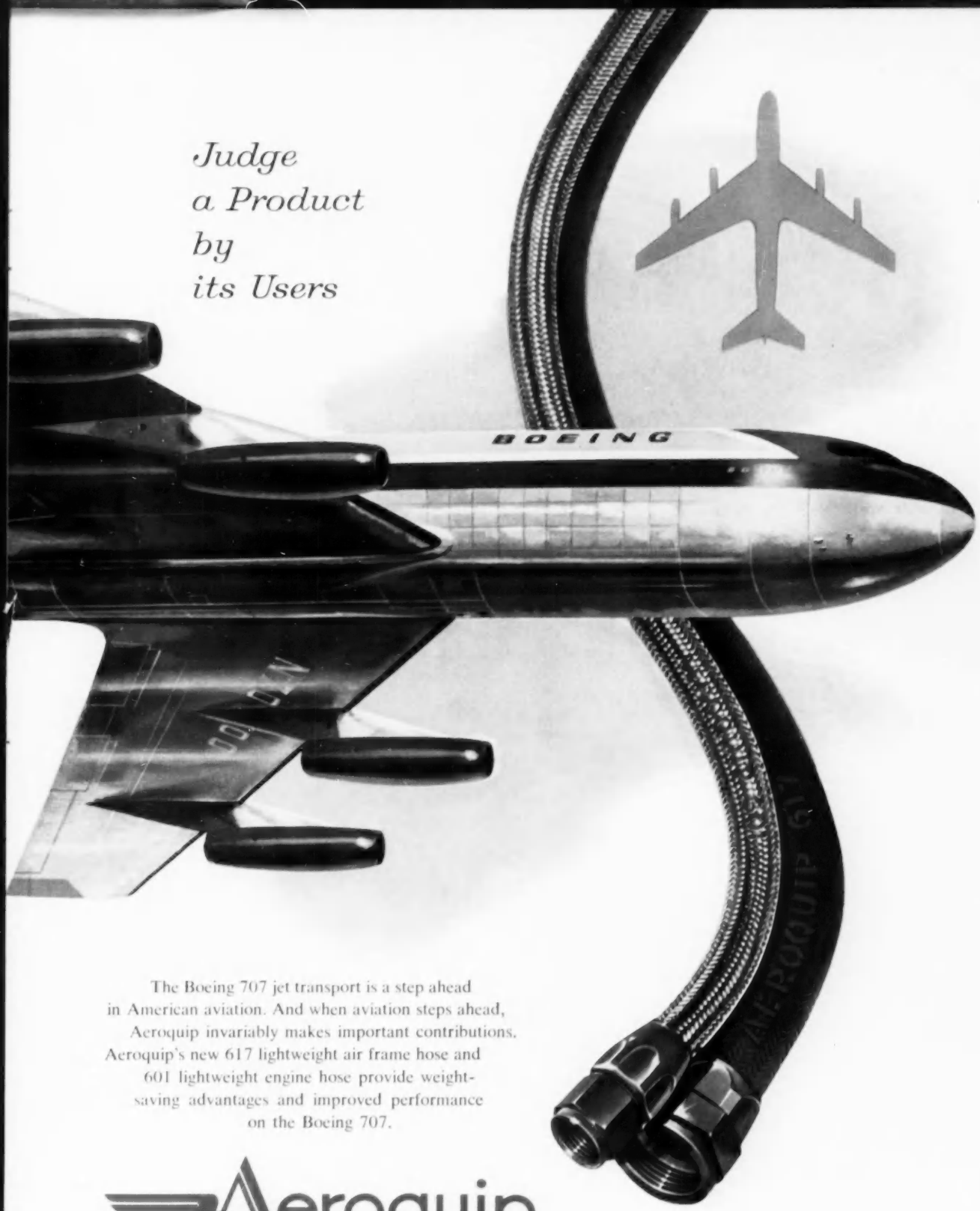
WARNER GEAR CO., LTD. (Canada)—synchronizer units for passenger cars and trucks.

ENGINEERING B-W PRODUCTION

Borg-Warner corporation

310 SOUTH MICHIGAN AVENUE • CHICAGO 4, ILLINOIS

Judge
a Product
by
its Users



The Boeing 707 jet transport is a step ahead in American aviation. And when aviation steps ahead, Aeroquip invariably makes important contributions. Aeroquip's new 617 lightweight air frame hose and 601 lightweight engine hose provide weight-saving advantages and improved performance on the Boeing 707.

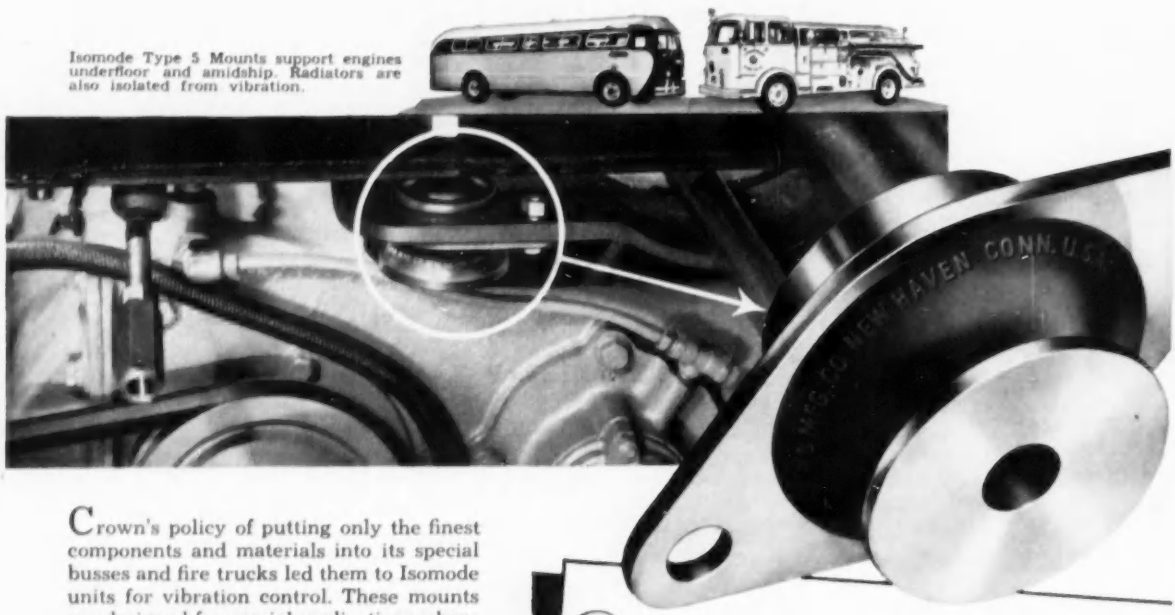
Aeroquip

Aeroquip Corporation, Jackson, Michigan • Aero-Coupling Corporation, Burbank, California (*A subsidiary of Aeroquip Corporation*)

Local Representatives in Principal Cities in U.S.A. and Abroad. Aeroquip Products are fully Protected by Patents in U.S.A. and Abroad.

ISOMODE® MOUNTS "...absorb vibration to a remarkable degree"

in Crown busses and fire trucks



Isomode Type 5 Mounts support engines underfloor and amidship. Radiators are also isolated from vibration.

Crown's policy of putting only the finest components and materials into its special busses and fire trucks led them to Isomode units for vibration control. These mounts are designed for special applications where performance and quality count most. From experience, Crown's choice has proved "more than satisfactory." Isomode mounts not only are tough, durable, but also absorb vibration to a remarkable degree.

In the coaches, Isomode Mounts support Hall-Scott, International Harvester, and Cummins diesel engines in amidship, underfloor installations. They also isolate radiators. They also assure smoothness in the famous Crown fire trucks designed with cab ahead of axle.

These various installations illustrate the versatility of Isomode mounts. With their design principle of equal stiffness in all planes, they isolate vibration from all directions, and work at any mounting angle.

As a principal source for special-performance mounts, MB may have the answer to *your* special vibration control problem. Contact us and see.

®*Trade Mark Reg. U.S. Pat. Off.*

Crown BODY & COACH CORPORATION

September 17, 1954

The M B Manufacturing Company, Inc.
1060 State Street
New Haven, 11, Connecticut

Gentlemen:

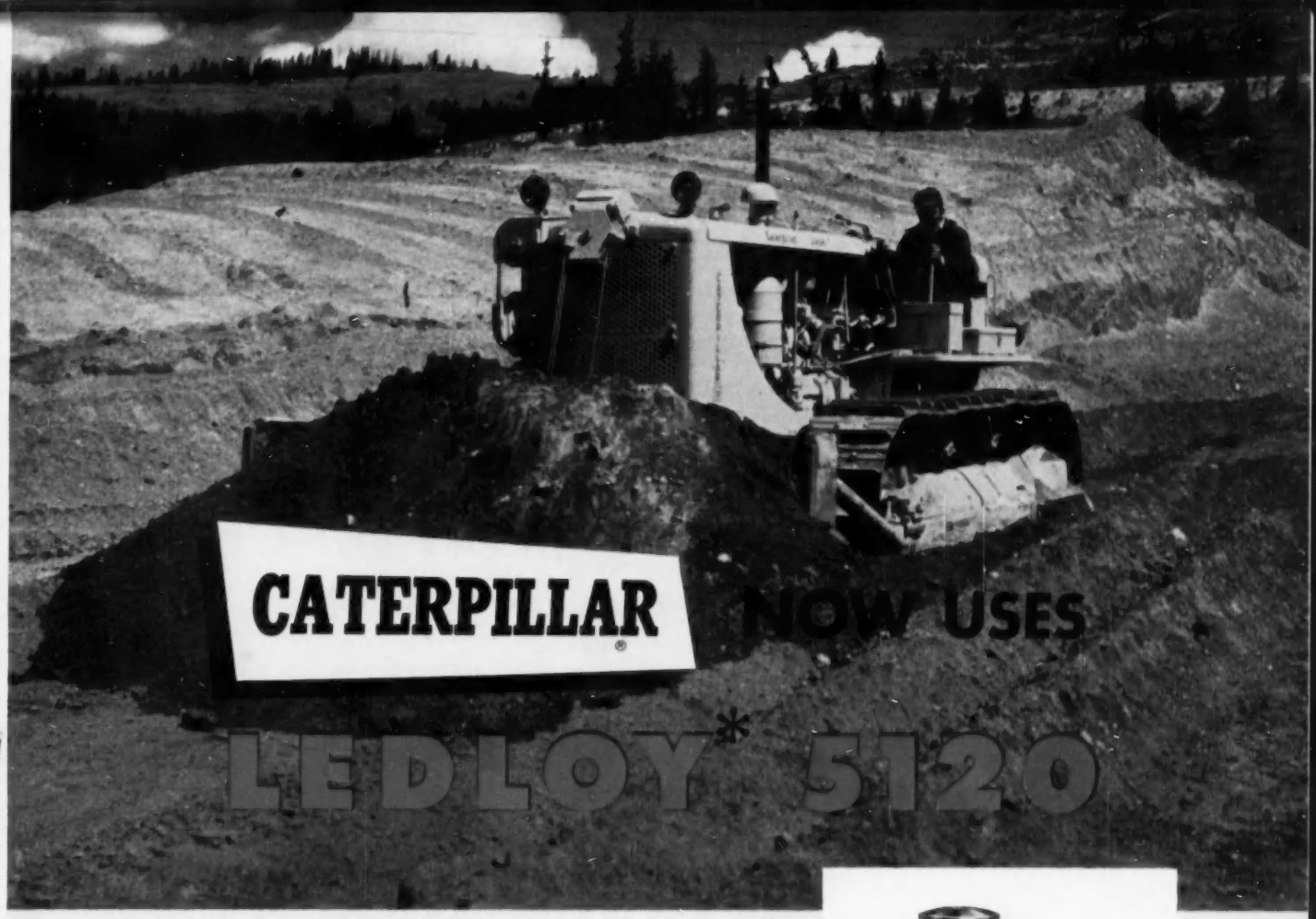
As you know, we have been using your Isomode mounts for quite a few years in the underfloor installation of our amidship motor coach engines and for our radiator installations. The majority of engines used are Hall-Scott, International Harvester and Cummins diesel. Consistent with our policy of selecting only the finest materials available, we chose your Isomode mounts. Our subsequent experience with them has indicated they are more than satisfactory. They are tough and durable, yet absorb vibration to a remarkable degree.

Our policy of maintaining top quality has resulted in our present position as the Nation's largest producer of transit type school buses, and we also build many Airporter, Sightseeing, and Intercity coaches. The quality of your product has contributed materially to the wide acceptance of our motor coaches.

the MB manufacturing company, inc.

1060 State Street, New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO *ISOLATE* VIBRATION...TO *EXCITE* IT...TO *MEASURE* IT



Saves on Every Pre-combustion Chamber Assembly

In today's competitive market, any savings on a component is important, even on a product as large as the Caterpillar D8 crawler Tractor. Caterpillar Tractor Co., with an eye on costs, selected Ledloy 5120 for pre-combustion chamber assemblies in their diesel engines. As a result, machining costs have been reduced on each of the two parts that form the finished assembly. This reduction resulted from Ledloy's free machining properties, which reduced machining time and increased tool life.

Design called for copper brazing the two pieces together and nickel plating the entire assembly. *The Method:* The leaded steel was brazed and plated in the usual way, without special handling. *The Results:* Pre-combustion chamber assemblies made of Ledloy 5120 at a lower cost, met all requirements and are seeing service in Caterpillar-built machines around the world.

*Inland Ledloy License

Two component parts of the Pre-combustion Chamber assembly were machined from Ledloy 5120 cold drawn bars. Other leaded alloy steels and leaded carbon steels are available in all standard or S.A.E. compositions in any of our standard sections. Write for complete information about application of leaded steels to your product.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY
(Steel Division) WARREN, OHIO

SEND FOR FREE BOOKLET ON LEAD-TREATED ALLOYS

in high fashion

YES — in styling that lifts the motorcar to new heights of beauty — in engineering that adds new reserves of power, sets new performance marks —General Motors' famous five for '55 are in a class by themselves.

For every car—even in the lowest and next-to-lowest price fields—displays such GM design advancements as the famous panoramic windshield, the longer, lower silhouette, with its swift, clean, sweeping lines.

and high compression

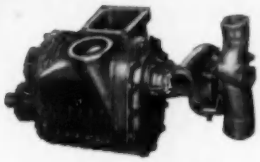
AND every car offers new proofs of General Motors leadership in the development of the high-compression engine and its teammate the automatic transmission. In fact, for the first time, a V8 is available in Chevrolet and Pontiac as well as Oldsmobile, Buick, and Cadillac. And Chevrolet offers improved Powerglide; Pontiac, Oldsmobile and Cadillac, smoother Dual Range Hydra-Matic; and Buick presents the new Variable Pitch Dynaflow.

These are only a few among the many contributions of GM stylists and engineers to motoring progress in 1955. Your dealer will be happy to add more complete and specific information as to why your key to any General Motors car is certain to be the key to higher style, higher power and performance — in fact, greater value.

GENERAL MOTORS
leads the way

CHEVROLET • PONTIAC • OLDSMOBILE • BUICK • CADILLAC
All with Body by Fisher • GMC TRUCK & COACH

The Country's Best
IN OIL AND GAS ENGINES
carry these
SCHWITZER-CUMMINS PRODUCTS



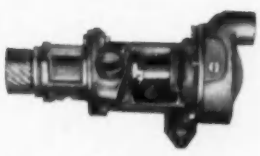
Positive displacement superchargers

Exhaust driven turbochargers

Automatic shaft seals

Crankshaft vibration dampers

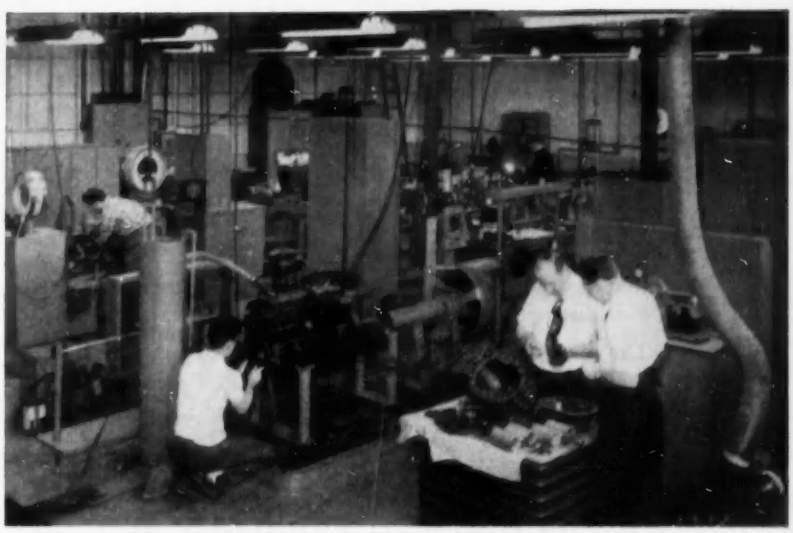
Fans for all industries



Engine cooling water pumps

Automotive oil pumps

For over a third of a century we have been major suppliers to all branches of the broad automotive industry. Our products have contributed much to the success of hundreds of blue ribbon internal combustion engines—large and small, mobile and stationary, land and marine, for all fuels, and for aircraft. We have acquired a wealth of engineering and field experience and ability to apply it to our customers' needs and manufacture our products economically. This experience and ability is available to you. Why not give us the opportunity to work with you on your new products or to improve current models?



Just a section of our complete and extensive facilities for developing and proving our product, for rubber research, dynamometer testing of engines, physical and chemical analysis and testing of materials.

SCHWITZER-CUMMINS COMPANY

1125 MASSACHUSETTS AVE. · INDIANAPOLIS 7, INDIANA

Air Starting Motors and Thermostatically Controlled Fan Drives manufactured for and sold exclusively by the Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio.

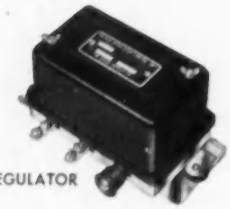
Leece-Neville

New Alternator System COSTS NO MORE than d. c. equipment

Completely redesigned from end to end, the new line of Leece-Neville Alternators are priced to make the entire L-N Alternator System . . . Alternator, Rectifier and Regulator . . . cost no more than d.c. equipment of comparable capacity.

ALTERNATOR

RECTIFIER



REGULATOR

ALL THE ADVANTAGES OF ALTERNATORS

The new Leece-Neville Alternators provide the many, well-known advantages over d.c. generators, including:

- Better performance on the vehicle through higher drive ratio. Alternators may be driven up to top bearing speed. See typical curves below.
- No commutator and no heavy current carrying brushes. Rotating field is excited through two small brushes riding on smooth slip rings.
- Unmatched reliability and long, service-free life. Complete overhaul involves just replacing bearings, slip rings and brushes.

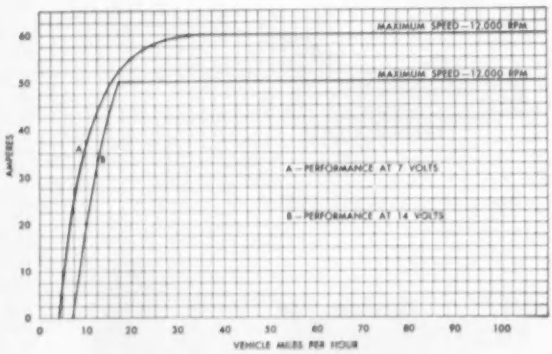
TYPICAL LEECE-NEVILLE QUALITY

In redesigning the L-N Alternator for low cost, volume production, nothing has been skimped. Engineering, materials and manufacturing are all up to the high standard that has made *Leece-Neville* synonymous with *quality* since 1909.

FOR 6-VOLT AND 12-VOLT SYSTEMS

The new line of Leece-Neville Alternators includes models for both 6-volt and 12-volt systems, with a choice of two bearing sizes to meet requirements of the application. All four models are on the same frame with identical external dimensions. System includes new, high density rectifier.

The new line of Leece-Neville Alternators offers the ideal solution for the increasing load of electrical accessories on passenger and commercial vehicles today . . . and tomorrow. For complete data, write The Leece-Neville Company, Cleveland 14, Ohio.



PERFORMANCE AT OPERATING TEMPERATURE

YOU CAN RELY ON Leece-Neville

AUTOMOTIVE ELECTRIC EQUIPMENT SINCE 1909

ALTERNATOR SYSTEMS • GENERATORS • STARTING MOTORS
REGULATORS • SWITCHES • FRACTIONAL HP MOTORS

TRUCK · BUS · DIESEL · OFF-HIGHWAY · PASSENGER · RAILROAD · MARINE · INDUSTRIAL

sleeve bearings
cast bronze bushings
bimetal rolled bushings
rolled split bushings
washers
spacer tubes
precision bronze parts

FEDERAL-MOGUL CORPORATION • 11035 Shoemaker • DETROIT 13, MICH.

SINCE 1899

FEDERAL Mogul **FEDERAL-MOGUL**

Something fresh and wonderful!

all-new PLYMOUTH '55

Biggest car of the low-price 3. . . . Powerful new V-8 and 6 engines . . . new chassis . . . new Metal-in-Motion Styling. . . . The all-new Plymouth is the car to measure against. This year, of all years, *look at all 3.*

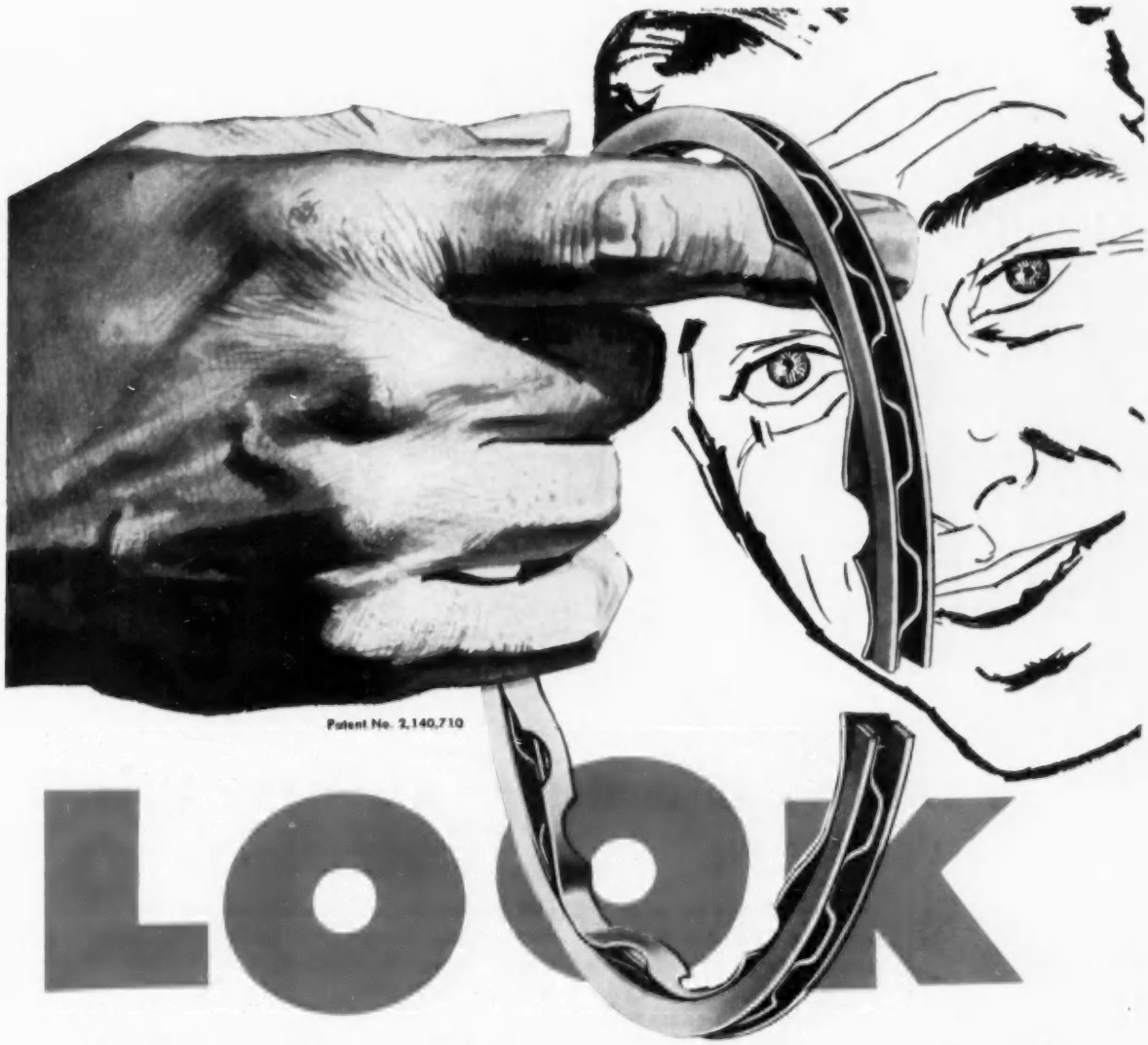
CHOICE OF TOP POWERPLANTS

177 hp . . . *Hy-Fire V-8 engine with PowerPak**
167 hp . . . *Hy-Fire V-8 engine*
157 hp . . . *Hy-Fire V-8 engine*
117 hp . . . *PowerFlow 6 engine*
*4-barrel carburetor at low extra cost

All powerplants available with PowerFlite, Overdrive or Synchro-Silent transmission

A great new car for the YOUNG IN HEART

See it and drive it at your Plymouth Dealer's!



LOOK

it handles like a one-piece ring!

NEW MUSKEGON

"UNITIZED"

CHROME PLATED OIL RINGS

MUSKEGON Piston Rings

MUSKEGON PISTON RING CO.
MUSKEGON, MICHIGAN
PLANTS AT MUSKEGON AND SPARTA

Since 1921... The engine builders' source!

You see at a glance that it's something new, different, better—a multiple-piece oil ring that *handles* like a one-piece ring!

But take a *good* look. See for yourself how Muskegon's patented *Unitizing* process holds the pieces together in the right order for quick, easy installation. Then, in the first rush of hot oil, as the engine starts to run, the special adhesive dissolves completely and leaves the parts of the ring free to function independently of each other.

Test Muskegon's CSR-200 rings in your own engines, in your own laboratory. See how the chrome plated rails reduce ring wear and bore wear, scuffing and friction—see how these rings keep the engine new longer and increase oil economy.

And your eyes will be wide with amazement when you learn that the price is just *half* that of chrome plated cast iron oil rings! Write us today.

DETROIT OFFICE: 521 New Center Bldg., Telephone Trinity 2-2113

announcing NYLABOND* automotive padding

. . . a new level in comfort — a new low in cost!

Gustin-Bacon takes pride in presenting NYLABOND — a new concept in automobile seat and trim padding. NYLABOND now takes its place with Amberlite, Satinaire, Ultrafine and Ultralite, in the G-B line of dependable products for the automotive industry.

Actually, this new material consists of millions of fine nylon "springs" welded together with strong bonds of plastic resin. Featherlight and downy-soft, NYLABOND absorbs shock *gradually*, without bounce or "throw" . . . provides a new level of passenger comfort. It has the durability and desirable properties of nylon itself, offers permanent resilience plus the ability to allow air passage as only a fibrous material can. Because it is considerably lighter than cellular materials, a pound of NYLABOND goes farther — costs less.

Today, NYLABOND is far more than a "product of promise" for the automotive industry. It has already passed field and laboratory tests of major manufacturers.

In addition to its many applications as seat and trim padding, NYLABOND is being used in filter applications and for wicking and lubricating purposes.

Automotive manufacturers interested in cutting costs without compromising passenger comfort can obtain NYLABOND samples and complete information from —

Skinner-Adams Company, 18323 James Couzens Highway
Detroit, Mich. **Tel: University 3-0300**

*Trademark Reg.

GUSTIN-BACON MANUFACTURING CO.
276 W. 10th ST.
KANSAS CITY, MISSOURI

gb

New York • Chicago • Philadelphia • San Francisco • Los Angeles • Houston
Tulsa • Dallas • Detroit • St. Louis

DOUBLE-DISC BRAKES
STOP YOU
184 FT. SOONER

TIME: *5 seconds to live.*

PLACE: *Any highway.*

SCENE: *You behind the wheel of your car.*

ACTION: *You're speeding along a highway.*

SUDDENLY an old car pulls out of a country road.

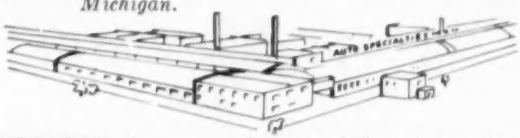
You jam your brakes to the floor. 471 ft. later you're breathing hard. You're alive. You're lucky. 471 ft.! *Remember that.*

You could have used a 184 ft. stopping advantage. If your car had been equipped with Auto Specialties Double-Disc Brakes, you would have come to a smooth, straight line stop in 184 ft. less.

Do you want to know more about these brakes? Then join me at another scene.

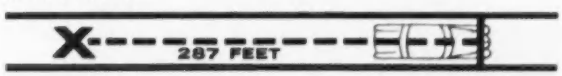
TIME: *Any day.*

SCENE: *Near Auto Specialties Mfg. Co., Saint Joseph, Michigan.*



ACTION: *A car races down a windswept concrete test strip.*

The driver hits the brakes. An electrical contact is broken . . . a chalk pellet marks the concrete where the driver first touched the brakes. Time: 5 seconds to live. 1-2-3-4-5—the car stops. Straight and square in the middle of the strip. No swerve marks. Engineers run a tape from the chalk mark to the stationary car. THE TAPE READS 287 ft.



More tests continue with various makes of cars at low and high speeds and under all weather conditions. Double-Disc Brakes consistently stop cars smoother, safer, quicker. They don't fade even after many repeated stops. They greatly reduce the danger of skidding. They provide the same proportional response to the same brake pressure under varying conditions.

Ausco Brakes have an automatic adjusting mechanism built into them, so rarely require adjustment during the life of an average car. Also, their larger braking area greatly reduces the need for relining. These brakes, constructed of aluminum, have the power built into them by means of their Self-Energizing design. The need for boosters or other outside mechanisms to step up braking power is thus eliminated.

Double-Disc Brakes are better brakes. Better brakes can save lives.

Auto Specialties Double-Disc Brakes have passed the tests at major car factories. They are now ready for cars. Most factories have test cars equipped with Auto Specialties Brakes. Ask to drive them.

AUTO SPECIALTIES MFG. CO.,

Saint Joseph, Michigan. Ask for "The Stopping Story."

Many products . . . One Standard I.Q.*

**Instrument Quality*

There is one characteristic common to all Giannini instruments—built to rigid, instrument-quality standards, they are instruments with an earned reputation of offering the utmost in mechanical and electrical design. High performance results from outstanding craftsmanship and rigorous calibration, testing and inspection procedures. Your job requirements can be met or exceeded by Giannini IQ instruments.

ACCELEROMETERS
Linear Transmitting

AEROHEAD TRANSMITTERS
Pitch, Yaw, Pitot, Static

GYROS
Free · Rate · Vertical Directional

POTENTIOMETERS
Low Torque · Slide wire, Linear, Non-Linear

MACH METERS
Transmission of Mach Number Information

PRESSURE TRANSMITTERS
Absolute · Differential · Gage Bourdon Tube

PRESSURE TRANSMITTERS
Capsule Type · Potentiometer or Synchro Output

TEMPERATURE PROBES
For Stagnation Temperature Measurement

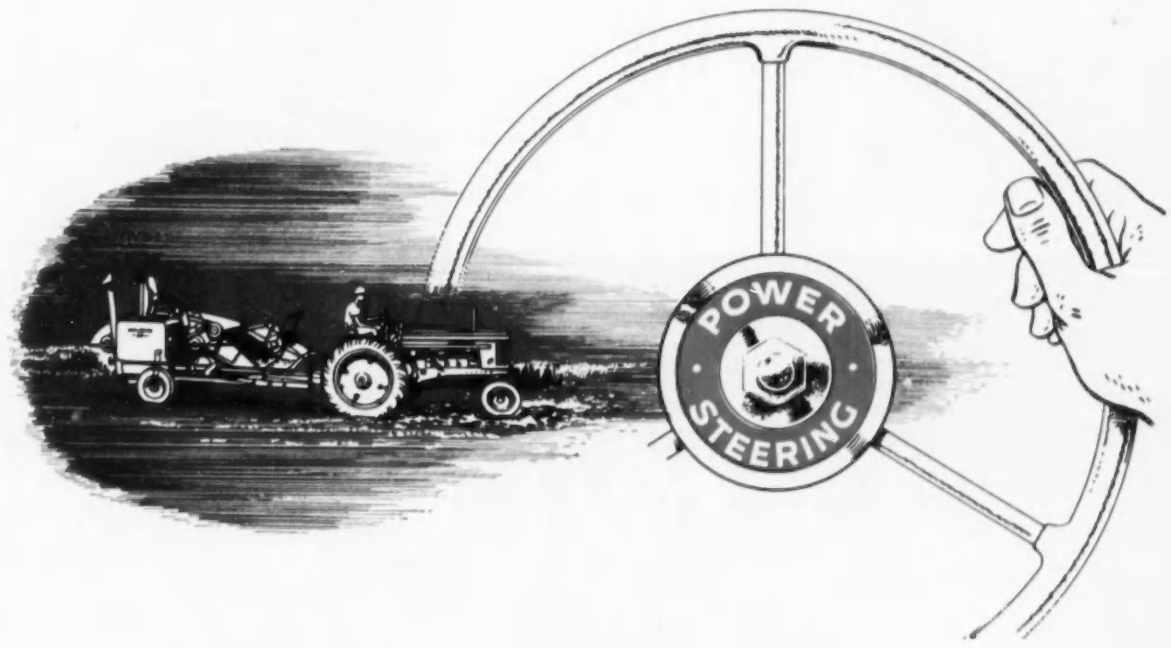
For catalog and engineering data on these and other fine instruments write:

INSTRUMENTS
CONTROLS

Giannini

G. M. GIANNINI & CO., INC. • PASADENA 15, CALIFORNIA • EAST ORANGE, NEW JERSEY

Another **JOHN DEERE** Engineering **first**



IT'S HERE—the latest in a long series of John Deere *firsts* in the farm equipment industry—*factory-engineered* POWER STEERING for a variety of row-crop tractors. To farmers, it's the biggest news in the row-crop tractor field in years, because it means *new* freedom from steering effort . . . *new* freedom from driver fatigue . . . faster, more convenient operation.

Every time the farmer takes the wheel, the tireless muscles of John Deere Power Steering save time and work. In deep sand or mud . . . bedded or irrigated land . . . over rough ground . . . working with loaders or other heavy, front-mounted tools . . . in extreme as well as in average conditions, John Deere Power Steering makes the difference of night and day in tractor handling.

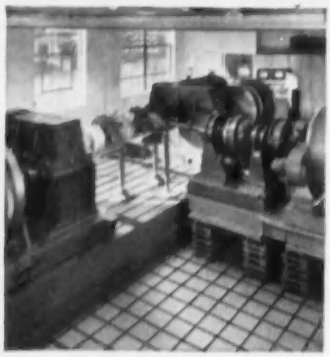
Of special engineering interest is the fact that John Deere Power Steering is an integral part of the tractor, not an attachment. A positive, gear-driven pump supplies hydraulic pressure—through a control valve—to actuate a steering vane which turns the front wheels at the operator's command. The vane is housed within a cylinder, completely concealed between radiator and grille and located close to the front wheels where the effort is needed. The entire unit is simple, compact, and quality-built to give years of trouble-free service.

John Deere Power Steering Tractors are the latest products of a continuous program of progress aimed toward serving the farmers of the country by providing, through the local John Deere dealer, the quality equipment needed to increase production, lower costs, and raise profits of agriculture.

JOHN DEERE

MOLINE, ILLINOIS

Quality Farm Equipment Since 1837



In the indoor "Torture-Chamber" TDA proves axle-gearing quality, too!

Here, we have capsuled a multi-thousand acre proving ground into one room! Here, our engineers can put 50 years' experience in building axles for trucks, buses, trailers, farm machinery, to use. Under scientific control and analysis, they run "shift tests," axle housing "bend tests," twist axle shafts 14° back and forth 36 times a minute, 24 hours a day, days on end. Or simulate a "chuck hole" shock every 4 seconds, 24 hours a day for months! A TDA exclusive!

WE SHIFTED TDA AXLES

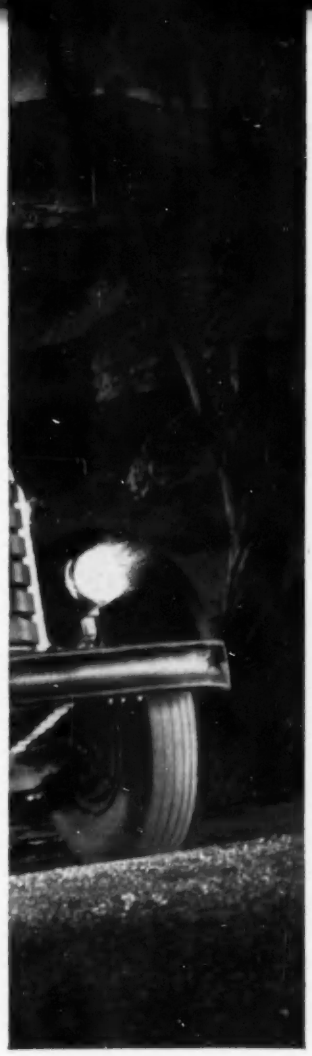
on 5 tractor-trailer combinations axle operation on record!

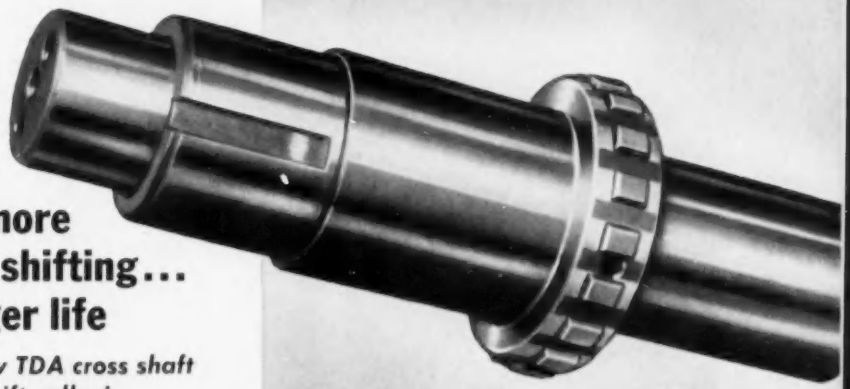
5 vehicles, averaging over 130,000 miles each—each averaging 2.7 shifts per mile . . . and all are still going strong!

Here's how TDA backs up indoor "Torture Chamber" tests with grueling outdoor, on-the-highway torture!

We installed 2-speed cross shafts and shift collar assemblies of the new TDA design, in five 5-ton tractor-trailer combinations. *Then the fun began!* Never before has there been such a murderous test of 2-speed axle shifting! All up and down the east coast, driving steadily day and night—shifting from fast to slow speeds and back again—averaging 2.7 times every mile, these tractor-trailers roared on to an average of over 130,000 miles apiece! That's 650,000 miles, 1,755,000 shifts in all—without noticeable wear, or repair stops. And the test goes on!

Meet our "Torture Tester"! With graphs showing speed and torque performance under any operating conditions he chooses—with special dials, recorders and electronic devices—he actually *drives* axles with scientific accuracy from his chair!





for more positive shifting... longer life

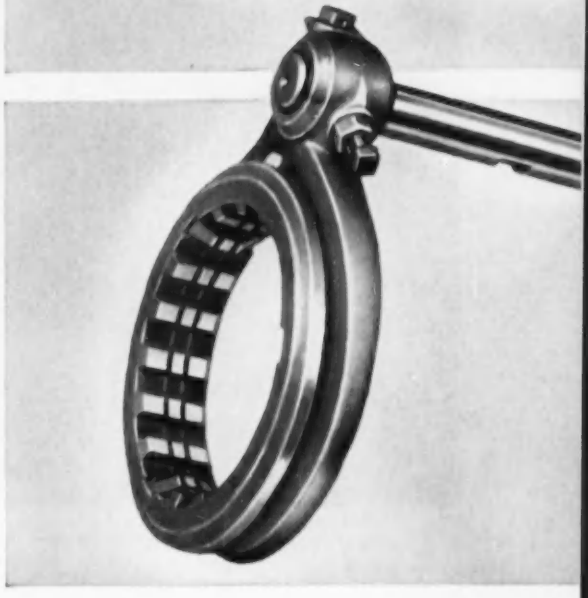
exclusive, new TDA cross shaft and shift collar!

Another TDA advantage! Only Timken-Detroit 2-Speed Axles have this advanced principle of shifting—"Torture-Tested" indoors, road tested under the most gruelling outdoor driving conditions ever! The result? Longer life, less maintenance, repairs and downtime; lower operating costs!

Note that in the new TDA Cross Shaft (above), a large *single row* of driving teeth gives greatly improved locking action with the new TDA Shift Collar teeth. Wear is reduced. There is no "hopping" out of gear.

New TDA Shift Collar (right), has *three* sets of teeth for driving and engaging — center teeth for locking only. Far less wear on engaging edges. Locking functions completely separated from driving and engaging functions!

Push-Button Operated. All TDA 2-Speed Axles are push-button shifted, with automatic activation by your choice of electricity, vacuum or air.



1,755,000 TIMES

...in the severest 2-speed

TIMKEN Detroit AXLES

TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

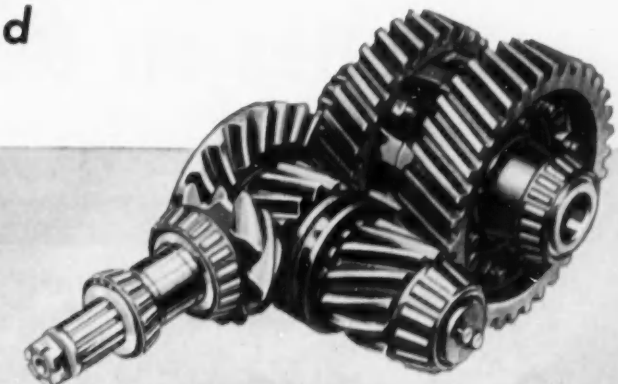
Accepted TDA 99 Standard

TRADE MARK REGISTERED

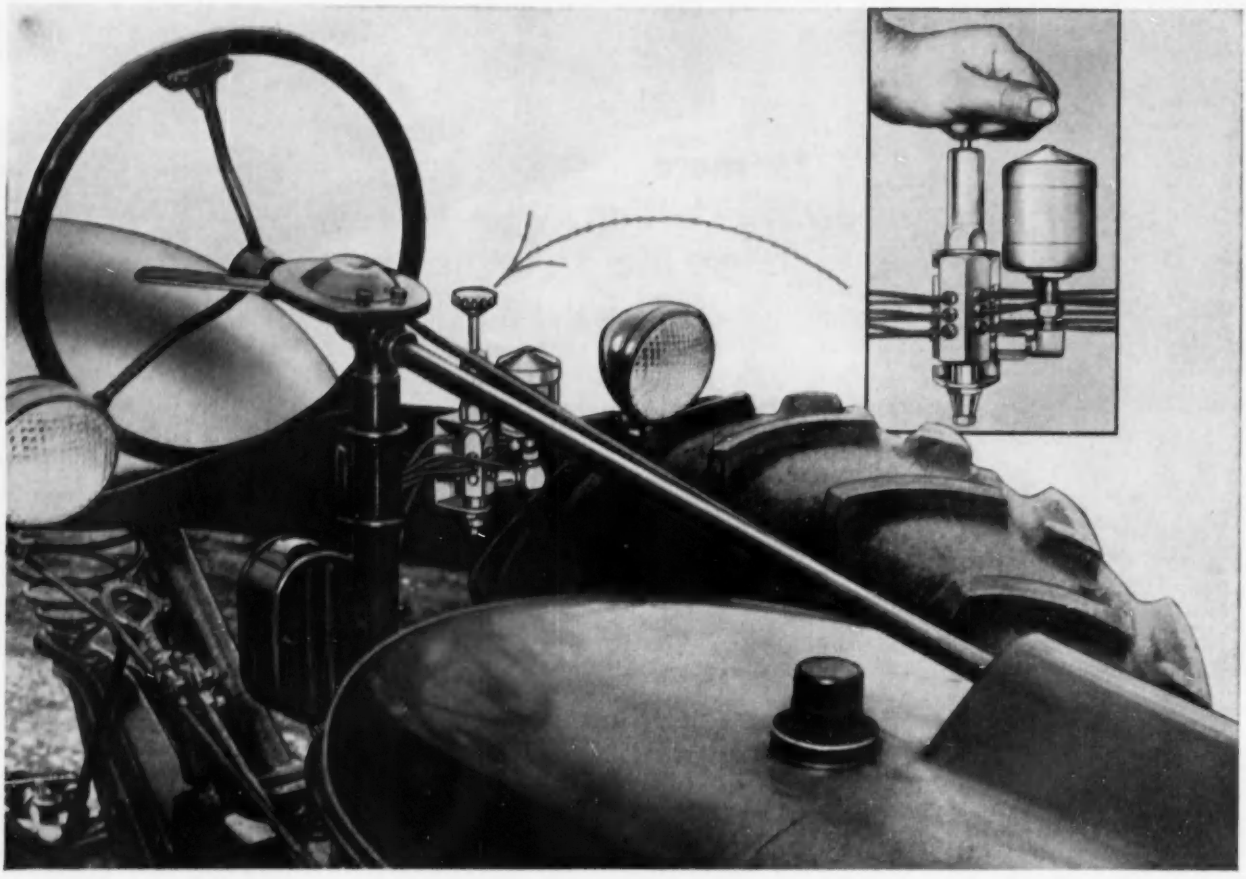
"TORTURE-TESTED"
to Save Money on the Job

World's Largest Manufacturers of Axles for Trucks, Buses and Trailers

Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York • Ashtabula, Canton and Newark, Ohio New Castle, Pennsylvania



Unequalled Gear Selection! TDA 2-Speed Axles are available in *three* different ratio "spreads" to meet any transmission-engine combination: 28%, 37% or 49%. Unlike ordinary designs that are limited to 37%, this TDA selection may be obtained simply by changing the low speed helical gear set. Exclusive, double-reduction design eliminates small, complicated parts. Man-size gears and bearings mean longer wear, quieter operation. Can operate in any gear ratio indefinitely without overheating!



Plunger handle for Multi-Luber is located near driver's seat for convenient operation. A few strokes of handle delivers an equal amount of lubricant to all vital bearings in seconds. Inset: closeup of pump handle, lubricant reservoir and Bundyweld feed lines.

New lubrication unit for farm equipment relies on Bundyweld

WHY BUNDYWELD IS BETTER TUBING

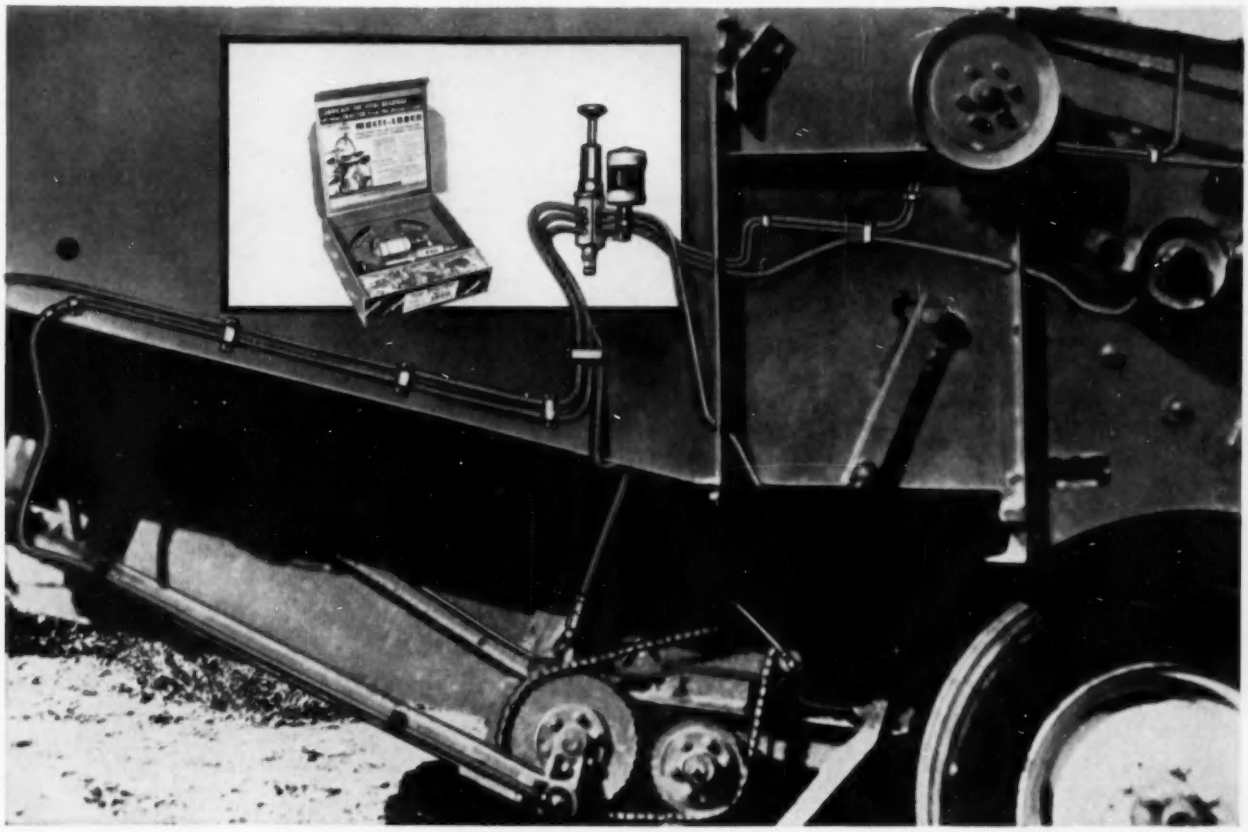
Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.



The Multi-Luber system comes in complete, easy-to-install kits, each designed for a particular type of farm equipment. Kits contain up to 75 feet of dependable Bundyweld, plus all parts needed for installation. Leakproof Bundyweld assures that lubricant will reach all vital parts, helps eliminate costly breakdowns. Multi-Luber unit is easily installed in field or shop, requires no special tools.

A new low cost system for lubricating farm machines is offered by the Lincoln Engineering Company's Multi-Luber. This easy-to-install lube system lets the operator "shoot" lubricant to all vital bearings of his farm machine without leaving his driver's seat or stopping the machine.

When the Lincoln concern sought a truly dependable tubing to carry the lubricant under pressure from its reservoir through tubing feed lines to the bearings, leakproof Bundyweld Tubing was their natural choice. Here's why:

Bundyweld is thinner walled yet stronger; can withstand heavy vibration fatigue, punishing wear; is leakproof by test; has high bursting strength; takes easily to standard protective coatings. It's the only tubing double-walled from a single metal strip, copper-brazed *throughout* 360° of double-walled contact.

In addition, this reliable tubing is backed up by expert engineering assistance; the industry's most technically advanced fabrication facilities; custom-packaging of orders; prompt, on-schedule deliveries. Let us help you with your farm machines, automobiles, trucks, or buses. Call, write or wire us.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Bundy Tubing Distributors and Representatives: ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Los Angeles 58, Calif.:*** Tubesales, 5400 Alcoa Ave. • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave., South ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**

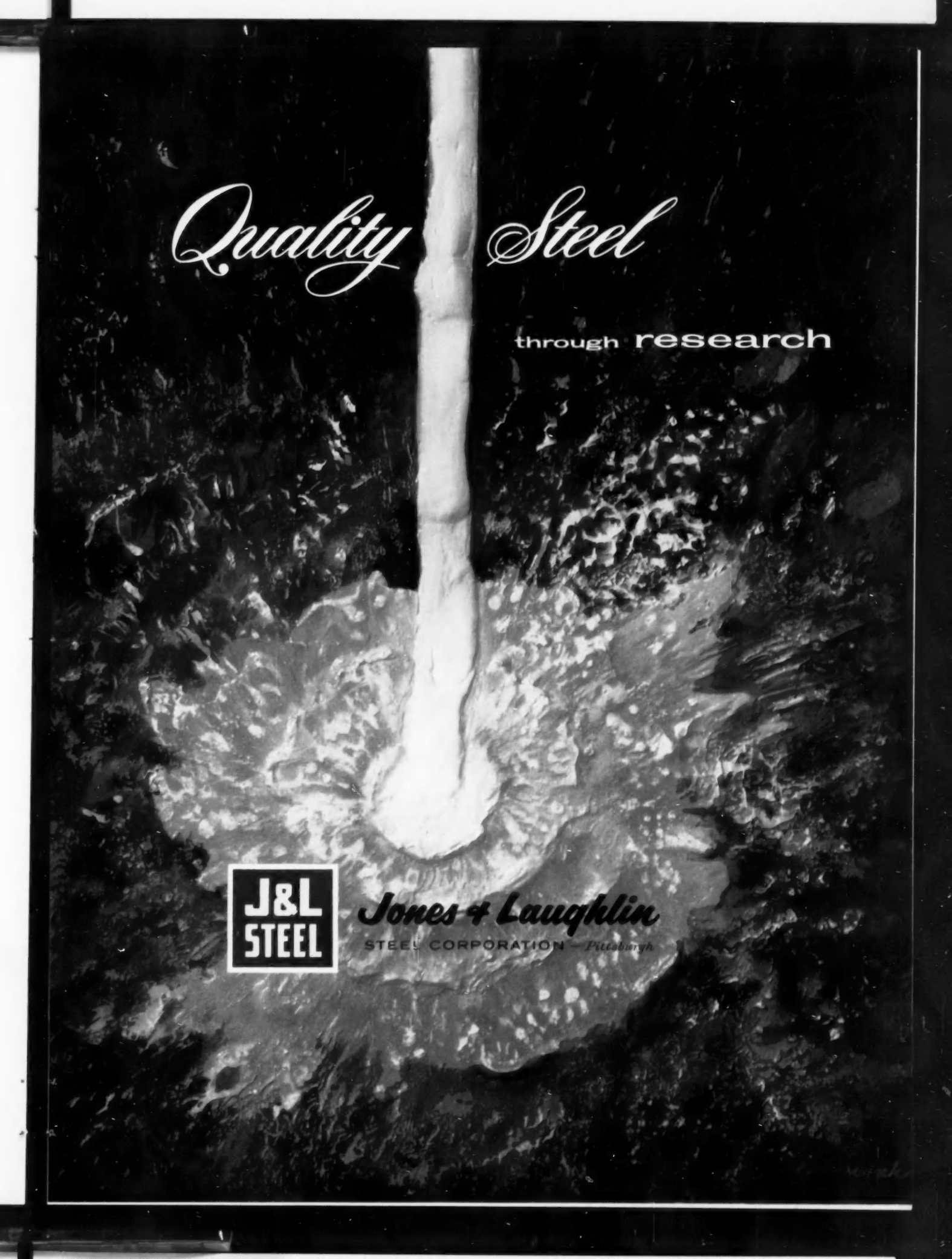
Highest styled, highest powered Mercury ever built!

The 1955 Mercury Montclair is designed with a bold new beauty in sleek, low lines—powered by a new 198-hp Super-Torque V-8 engine. Within Mercury's three new series—10 dramatically new models—is the Mercury that's exactly right for you. You can see it now at your Mercury dealer's, so visit him soon.

it pays to own a **MERCURY**

for future styling, super power

MERCURY DIVISION • FORD MOTOR COMPANY


Quality Steel
through research
J&L STEEL
Jones & Laughlin
STEEL CORPORATION — Pittsburgh

7,000 ITEMS A KEY TO K&E LEADERSHIP

Drafting. Reproduction. Surveying.
Optical Tooling Equipment and Materials
Slide Rules Measuring Tapes

KEUFFEL & ESSER CO.
EST. 1867
New York · Hoboken, N. J.
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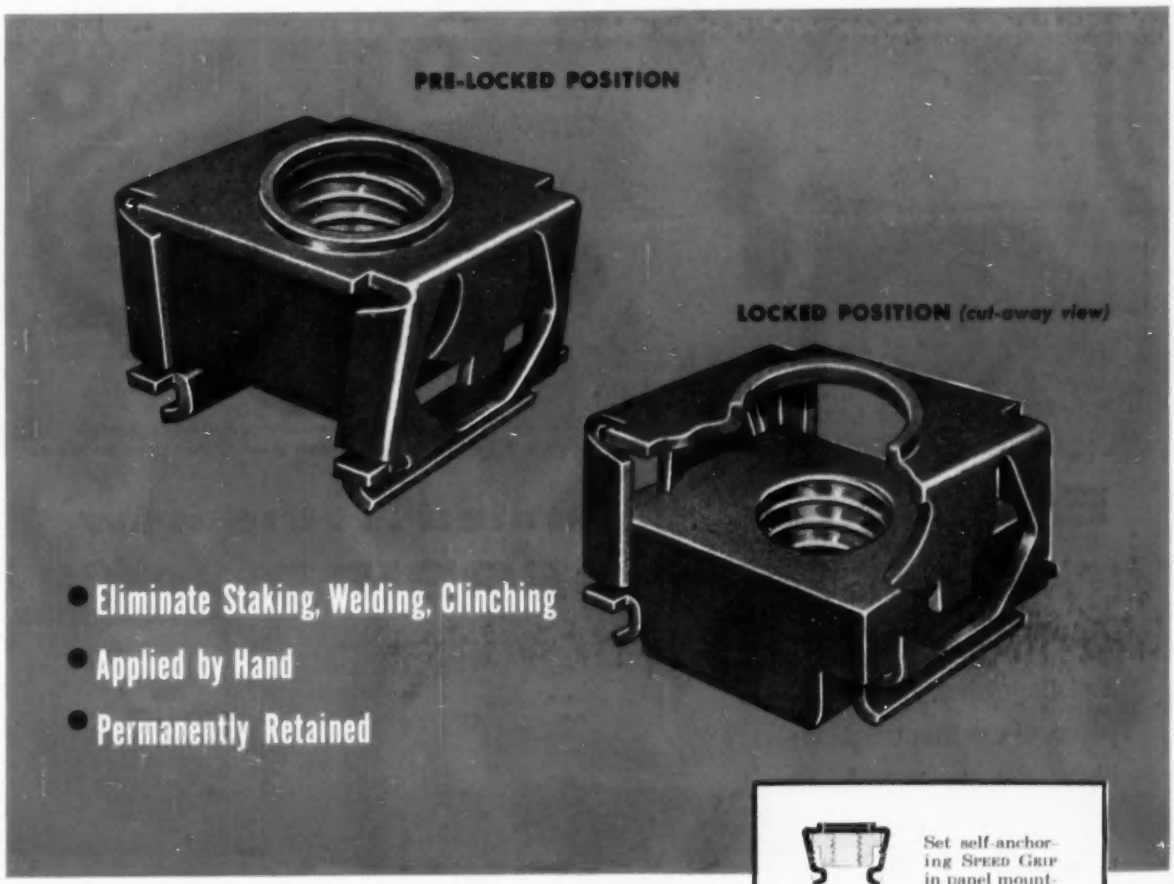
• Since 1867 engineers, scientists, designers, surveyors, draftsmen have relied on K&E as the foremost, most progressive, and most complete source of supply for the tools, equipment, and materials they work with. When you buy, think first of K&E, headquarters for 7,000 items. For example . . .

LEROY® LETTERING SETS

The diversity of alphabets, numerals, symbols, trademarks and other designs available from stock or made to your special order, is almost unlimited with Leroy Lettering Equipment. You can have practically anything you want.

In Leroy Lettering each letter and number can be drawn complete without shifting the template. This ease and simplicity of operation, combined with the consistent uniformity of the lettering, has made Leroy Lettering Sets a "must" in thousands of drafting rooms the country over.



New, Self-Anchoring SPEED GRIP®

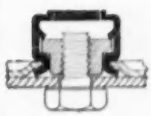
cuts assembly costs in half!

Whatever your present method of attaching square nuts to panels, new self-anchoring SPEED GRIPS can do the job faster, easier, better. This unique fastener has spring steel "mechanical hands" that permanently lock the nut in bolt-receiving position. It cannot be dislodged even with rough handling. Applied after painting or porcelainizing, there is no clogging, retapping or masking of threads to bother about. *And* it is ideal for blind location attachments.

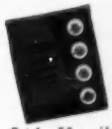
Total up the savings in application time—in expensive assembly equipment—in handling time—in assembly steps—and you'll switch to self-anchoring SPEED GRIPS—the newest addition to the complete Tinnerman line of Nut Retainers.

Set self-anchoring SPEED GRIP in panel mounting hole.

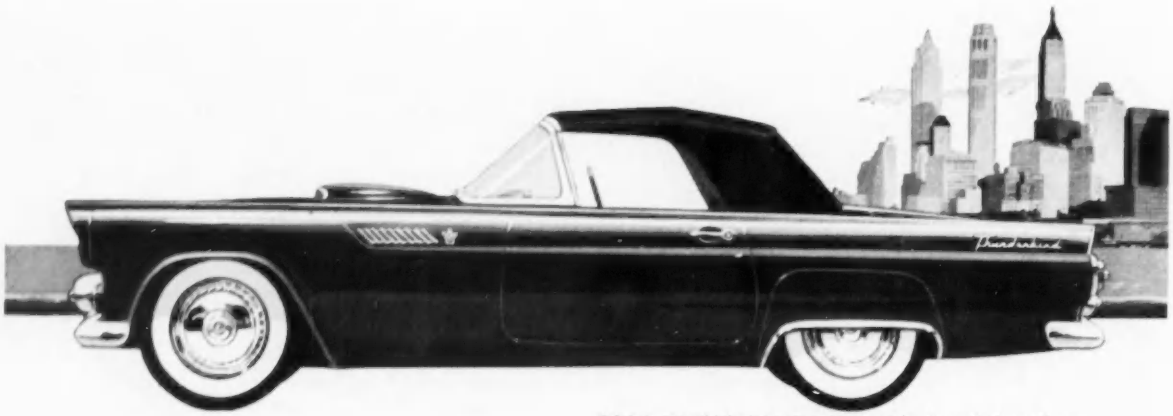
Simple tool presses nut into locked position.



Heavy duty nut in locked position — permanently retained — can't rotate, rattle or be dislodged.



Write today for free copy of new detailed SPEED GRIP Bulletin, No. 335. Tinnerman Products, Inc., Dept. 12, Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners Ltd., Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S.A., 7 rue Henri Barbusse, Levallois (Seine).



A fabric top whisks into place in seconds—to protect you from sudden rainstorms. It's completely out of sight when not in use.

Enchantment unlimited . . . the new Ford THUNDERBIRD

A distinguished kind of personal car that combines high performance and high style for a whole new world of driving fun.

Those long, low lines . . . the sweeping, contoured windshield . . . say distinction in every detail.

THE Thunderbird's long, low, thoroughbred lines say "action"! And they speak the truth.

A toe-touch on the gas pedal means *no waiting.*

There's breath-taking Trigger-Torque performance with the new Thunderbird Special V-8 . . . 198 h.p. with Fordomatic, 193 h.p. with Overdrive or Standard transmission.

With a low center of gravity (from cowl to ground is just over three feet) and Ford's Ball-Joint Front Suspension, the Thunderbird corners with maximum ease and stability.

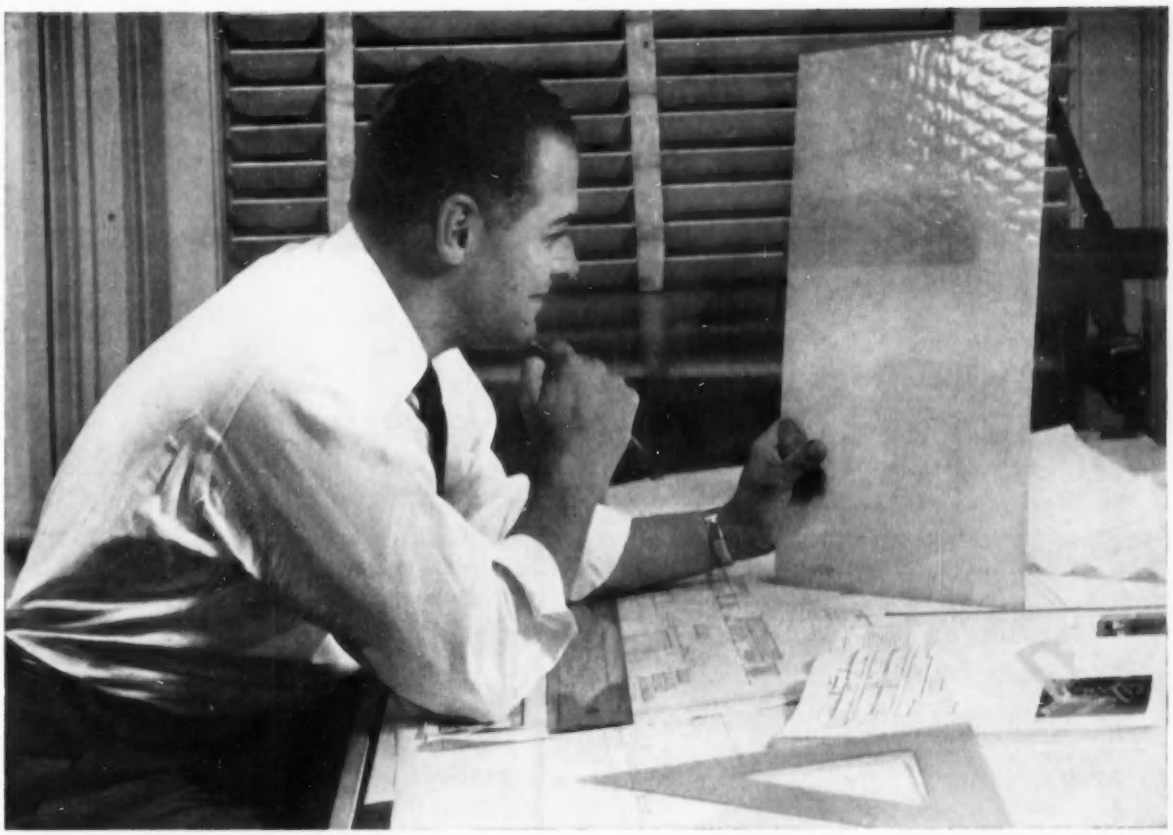
The fun doesn't stop here, for the Thunderbird is *long* on convenience.

Two tops are available. There's a removable hard top . . . and a smart convertible fabric top. Windows *roll* up. The extra-wide foam-rubber-cushioned seat moves forward or back, up or down, at the touch of a button. The baggage compartment is ample. There's a telescoping steering wheel. And you can have power steering, power brakes and power windows.

Why not get complete details from your Ford Dealer today?

The removable hard top is easy to handle . . . locks into place to give you winter-long comfort.

FORD MOTOR COMPANY— FORD • LINCOLN • MERCURY CARS • FORD TRUCKS • TRACTORS • INDUSTRIAL ENGINES



Now you can get polyester laminates with ***specific flame resistance***

If it is an application where you can use the structural strength or the style imparted by modern glass-reinforced polyester sheets . . . but need *permanent, specific fire resistance* . . . ask your fabricator or molder for laminates made with HETRON® polyester resin.

HETRON'S flame resistance, which distinguishes it from virtually all other resins, is chemically locked in. The result is unique stability. There is no loss of mechanical properties, as may occur when flame resistance is obtained through the use of additives alone.

HETRON resins have the added advantages of high chemical resistance, shrinkage on cure averaging 5%, a heat distortion point of 220° F. for HETRON 92, and water absorption for the same material of 0.26% after 7 days' immersion at 73° F.

In short, HETRON resins offer you all the advantages of a good polyester material—easy moldability, machinability, and adaptability—*plus* the fact that they are self-extinguishing.

We supply the resins only, but will be glad to send you names of molders and fabricators who make HETRON-based sheets. Write also for technical data and specifications on HETRON resins.

FLAME TEST proves sheet made with HETRON polyester resin does not burn freely with exposure to blowtorch flame. Veneered wood, used as basis of comparison, ignites from candle flame and burns to destruction in five minutes.

HOOKER CHEMICALS

6-1955

1905—Half a Century of Chemicals
From the Salt of the Earth—1955

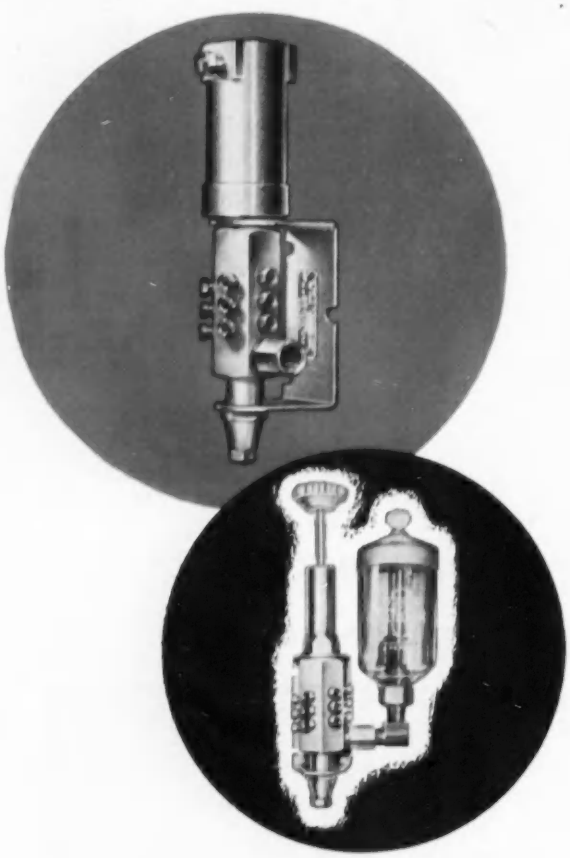
HOOKER ELECTROCHEMICAL COMPANY

38 FORTY-SEVENTH ST., NIAGARA FALLS, N. Y.

NIAGARA FALLS • TACOMA • MONTAGUE, MICH. • NEW YORK • CHICAGO • LOS ANGELES

announcing the Multi-Luber*

ANOTHER HISTORY MAKING DEVELOPMENT



Air-Operated

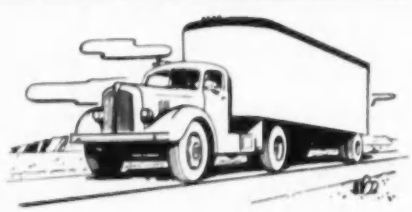
Adopted by leading fleet and bus operators for automatic, controlled application of lubricant to bearings each time driver applies the air brake. Complete Systems available in handy kits for immediate installation. Air-Operated Multi-Luber Systems may be used effectively wherever compressed air is available as motive power. They are slashing operating costs and increasing performance efficiency on equipment ranging from transport trailers to automated lathes and packaging machinery.

For applications where compressed air is not available, the air cylinder of the Multi-Luber can be replaced with a manually actuated pushbutton. These Systems are also available in convenient kits for quick installation on tractors, farm implements and a wide range of industrial machinery for positive, dependable lubrication in seconds.

*Trade Name Registered Patent Pending

APPLICATIONS UNLIMITED

Wherever wheels and shafts turn . . . wherever it is necessary to maintain a constant, protective film of refinery-pure lubricant on bearing surfaces, there is an application for a Lincoln Power Lubrication System. Lincoln Engineers will be glad to show you how Controlled Power Application of the Right Lubricant, in the Right Quantity, at the Right Time can add multiple sales features to your product, or slash operating costs on existing facilities. Just let us know how and when we can be of service.

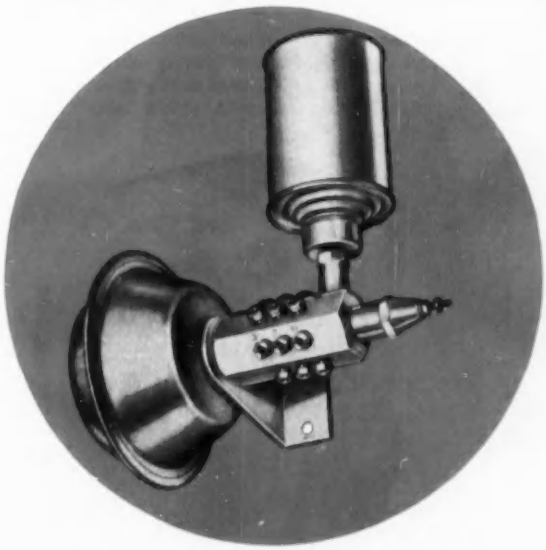


TRACTORS AND TRAILERS

LINCOLN ENGINEERING COMPANY • St. Louis 20, Missouri

systems for POWER LUBRICATION

FROM *Lincoln* ENGINEERING COMPANY . . .



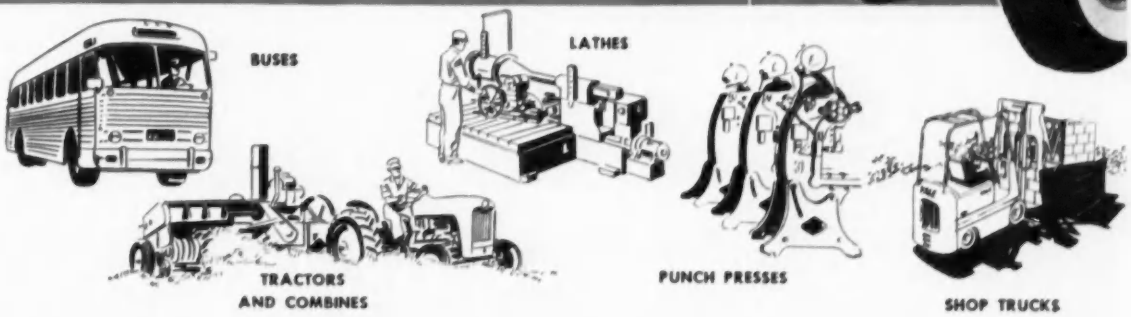
Vacuum-Operated

Multi-Luber Systems are also available for instantaneous, automatic lubrication of equipment ranging from light trucks to fork lift trucks, or any application which makes available vacuum as motive power.
A fingertip touch of the control button, located wherever desired, assures that a pre-measured quantity of refinery-pure lubricant is applied with positive uniformity by the Multi-Luber sealed system.

AND NOW . . . AVAILABLE ON 1955 model

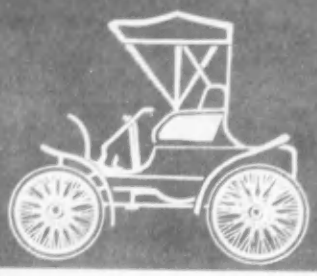
LINCOLN and MERCURY motor cars

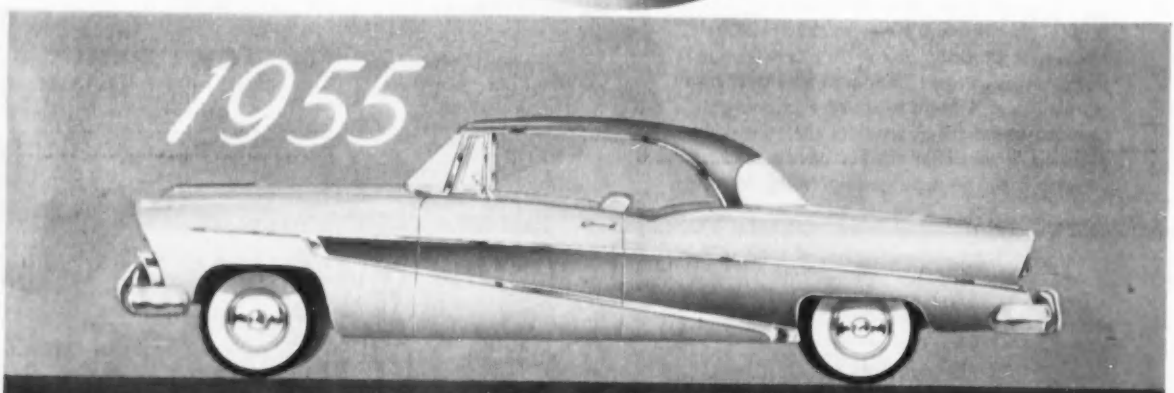
Here is the newest and most revolutionary application of Lincoln's Vacuum-Operated Multi-Luber System. Now purchasers of new Lincoln or Mercury motor cars have available instantaneous Power Lubrication at their own convenience. A mere touch of a button on the instrument panel provides the continuous pleasure of smoother car performance, greater steering ease and increased operating economy.



PIONEER BUILDERS OF LUBRICATING EQUIPMENT FOR A QUARTER-CENTURY

1898





MARLIN-ROCKWELL CORPORATION

Executive Offices: Jamestown, N. Y.

Factories: Jamestown, N. Y. Plainville, Conn. Falconer, N. Y.

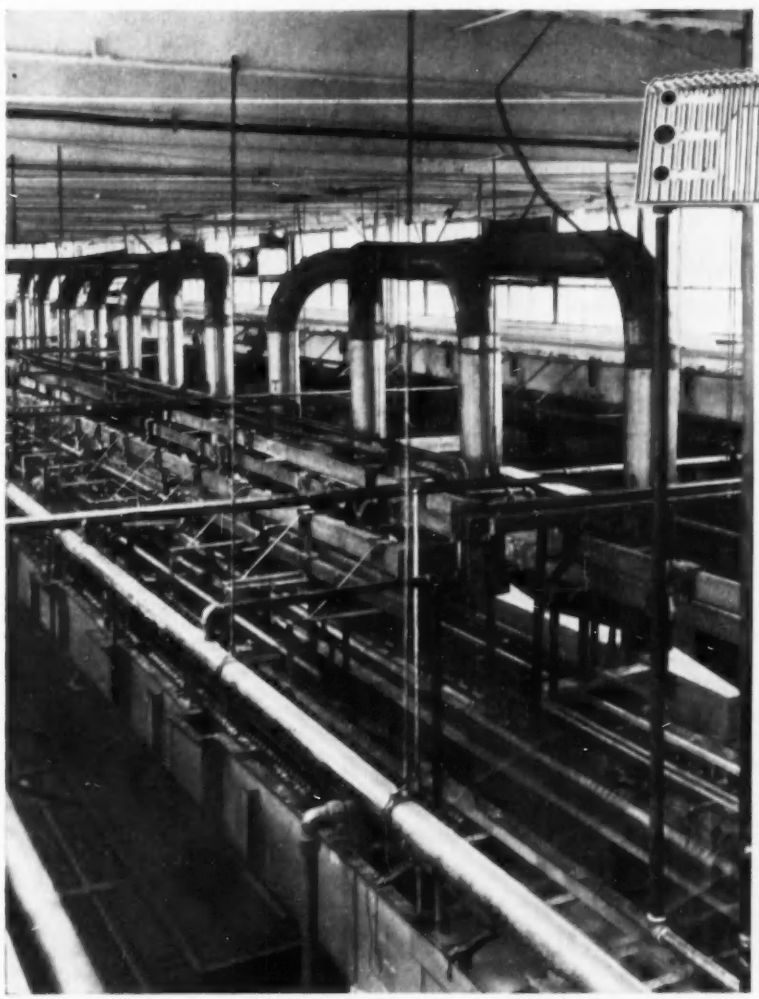
THIS 160 FEET OF AUTOMATION AT GERITY

BRINGS YOU FINER, MORE UNIFORM PLATING AND SPEEDIER DELIVERIES

The newest in automation has come to Gerity. A fully automatic, 160-foot electroplating machine is in and operating—turning out glittering radiator grilles, emblems, ornaments, hardware and trim for America's most popular cars.

What's important is this. Gerity—the world's largest independent, exclusive plater—is now set up to handle more orders more swiftly than ever before. So great is the capacity of this giant machine, it can handle many different volume plating jobs simultaneously. And, because it times dipping cycles so perfectly, you can expect Gerity Chrome to hit new highs in luster and in uniform high quality.

If you have a plating problem, go to Gerity. You'll find all Gerity Chrome is heavy, thick and tough—the kind that won't flake, pit or blister. You'll get speedier service, too—deliveries keyed to meet your most exacting production demands.



PARTS RANGING FROM LARGE automobile grilles to tiny ornaments are plated brilliantly and exactingly in this huge, new Gerity electroplater. Completely automatic, the machine is 160 feet long, 9 feet wide and 16 feet high . . . equipped with 29 solution tanks including a copper tank holding thousands of gallons.

Modern facilities like this assure Gerity customers of finer chrome, faster service.

GERITY-MICHIGAN CORPORATION
ADRIAN, MICHIGAN

Gerity

Sensational Piston Performance

UNIFORM CLEARANCE AT ALL TEMPERATURES

STEEL TENSION MEMBER

Anchored only at pin bosses and cast in positive contact with I. D. of piston skirt

Controls Clearance Automatically

ZOLLNER CLEAR-O-MATIC PISTONS

Now, pistons may be fitted to closer clearances than ever before possible. The sensational development of CLEAR-O-MATIC Pistons by Zollner engineers *reduces required clearance to less than .001 with constant uniformity of skirt bearing over the entire temperature range.* Performance results are spectacular. Engines run quietly with no cold slap. Friction is reduced without loss of durability or heat conductivity. There is no danger of scuffing or seizing. The Zollner designed steel tension member incorporates in the aluminum piston the same effective expansion as the ferrous cylinder itself. We urge your immediate test of these sensational advantages for your engine.

Design adaptable to full skirted or slipper-type pistons for gasoline engines for every purpose.

UNIFORM EFFECTIVE SKIRT CLEARANCE AT ALL TEMPERATURES

1. Clearance maintained uniformly at all coolant temperatures from 20° below zero to 200° F.
2. Effective expansion identical with ferrous cylinder.
3. Steel tension member, with same effective expansion as cylinder, maintains uniform skirt clearance through entire temperature range.
4. Normal diametric clearance usually less than .001 with uniform skirt bearing.
5. Durability and conductivity comparable to heavy duty design.

ZOLLNER PISTONS

THE ORIGINAL EQUIPMENT PISTONS

ZOLLNER

- **ADVANCED ENGINEERING**
- **PRECISION PRODUCTION**

in cooperation with engine builders

ZOLLNER MACHINE WORKS • Fort Wayne, Indiana

HYDRAULICS FOR MOBILE EQUIPMENT

VOL 2

Mobile Equipment News

VICKERS INCORPORATED, DETROIT, MICHIGAN

IMPROVES PERFORMANCE • CUTS COSTS

NO. 3

New! VICKERS HYDRAULIC POWER STEERING BOOSTER...SERIES S23

LATEST DEVELOPMENT in POWER STEERING for TRUCKS, BUSES, MATERIALS HANDLING VEHICLES, ROAD CONSTRUCTION and MINING MACHINERY

More compact . . . improved in operating characteristics . . . this new Vickers Steering Booster, Series S23 is an important new development in power steering for many vehicles. Application is much easier because it requires less space . . . and ultimate costs are substantially lower. Series S23 thus opens the way to fingertip ease of steering for a wide range of additional vehicles.

Like the preceding models, Series S23 has hydraulic lock against road shock. Bumps, chuckholes, blown front tires, obstructions, etc., cannot spin the steering wheel or jerk it out of control. This is a safety factor of great importance.

Series S23 Boosters are provided either with (Model S23R) or without (Model S23N) an integral relief valve. Model S23N is used with Vickers VT16 and VT17 pumps that have integral volume control and relief valve. When the larger volume Series V200 pump is used and a volume control is required in the circuit, the S23N is used with a separate combination valve (see Series FM2 below). Model S23R is used with the Series V200 pumps that have no integral valving, for applications where a volume control is not required.

ASK FOR NEW BULLETIN M5106

MORE VERSATILE INSTALLATION

In Series S23 Boosters, the servo ball stud housing is symmetrical, and can be assembled in any one of four positions. This and the compactness of the Booster makes application easier . . . increases the number of applications which can be made without major engineering changes. Series S23 Boosters can be mounted interchangeably with Models S6-277 and S6-279 Boosters.

REQUIRES LESS SPACE

The new booster has been reduced in size by the redesign of the servo control valve. The tube connecting the servo valve to the rod end has been relocated and is now on the same side as the fitting connection. As a result of these changes, Series S23 requires less space . . . works in closer quarters.

7062

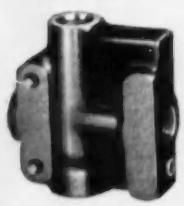
VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1440 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO AREA (Brookfield) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N. J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) SEATTLE • ST. LOUIS • TULSA • WASHINGTON • WORCESTER

VICKERS VOLUME CONTROL and OVERLOAD RELIEF VALVE



Five sizes of Series FM2 Valves were developed primarily for hydraulic power steering on trucks, buses and materials handling equipment where the pump does not include a volume control valve. The FM2 improves steering booster performance by providing a relatively constant volume of oil regardless of engine speed variations. An integral relief valve is included.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Show people a "Show-Car" like

THE MOTORAMIC CHEVROLET

and you'll pack 'em in like this! . . .

(Maybe this will give you some idea of what has happened at Chevrolet Dealer showrooms throughout the country since Announcement Day!)

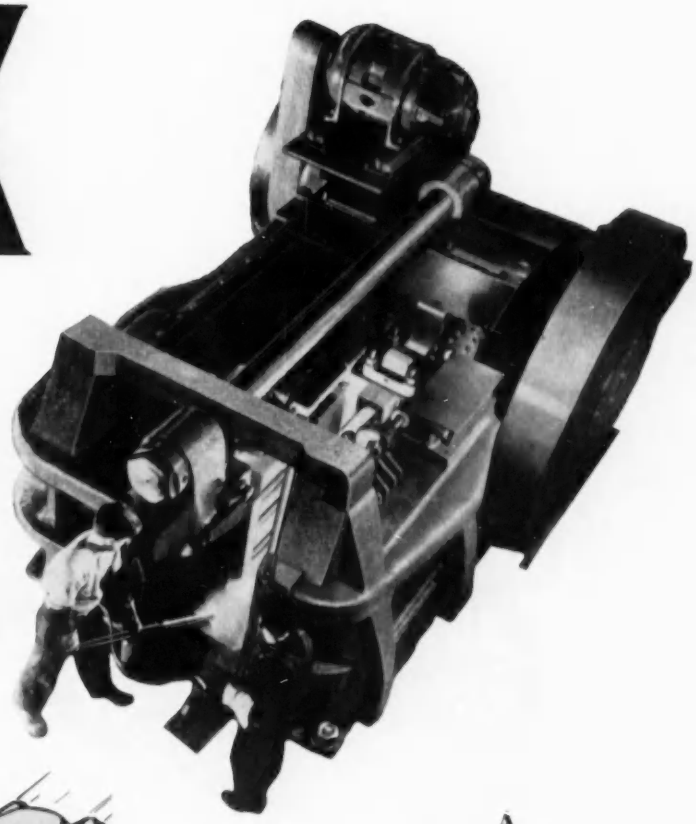
New Products
New Progress

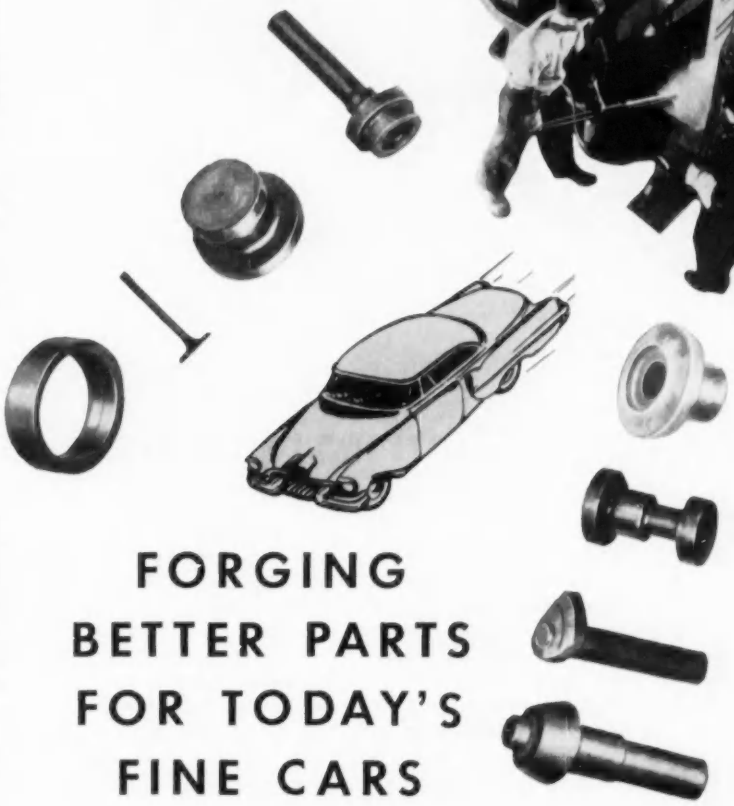
CHEVROLET

for a New Era
of Leadership!

AJAX

FORGING MACHINERY





FORGING
BETTER PARTS
FOR TODAY'S
FINE CARS

A
Complete Line
of
FORGING PRESSES
FORGING MACHINES
and
FORGING ROLLS
To Meet The Needs
of
The Forging Industry

— write for Descriptive Literature —

THE *Ajax* MANUFACTURING CO.

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Reeves 1911 Octoauto made at Columbus, Ind.

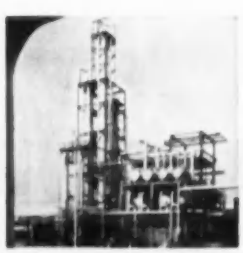
What happened to the four extra wheels?

Spectacle and progress are not always synonymous. Take the 1911 Octo-auto. Those four extra wheels made it the most spectacular vehicle ever to shatter the silence of a country road—yet they rest today on the scrap heap of history.

Then consider alloy steels. They *look* like ordinary metals. Yet they drill the hardest rock . . . bridge the widest rivers . . . muffle the blasts of the fastest jets. "Made to order" with Vancoram ferro alloys, they boost the capacity, safety and economy not only of today's automobiles but of virtually every modern machine and structure.

To help America's steelmakers meet the growing demand for alloy steels, Vanadium Corporation produces ferro alloys of vanadium, boron, chromium, silicon, manganese and titanium. Its integrated network of mines and mills is also a primary source of aluminum alloys and uranium for atomic energy.

A nation on wheels, America now owns close to 47,000,000 automobiles—and each one is safer, stronger, more powerful because critical engine parts and structural members are made of special alloy steels.



Heat- and corrosion-resistant alloy steel processing equipment helps the expanding petroleum industry increase the world's supply of gasoline, fuel oil, lubricants and scores of other petroleum products.

Designed to hang in mid-air or to blast the sonic barrier, today's aircraft depend upon "made to order" alloy steels. This is true for every modern mechanical product from rock bits to diesels, kitchen knives to bridges.

VANADIUM CORPORATION OF AMERICA

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Pittsburgh • Chicago • Detroit • Cleveland

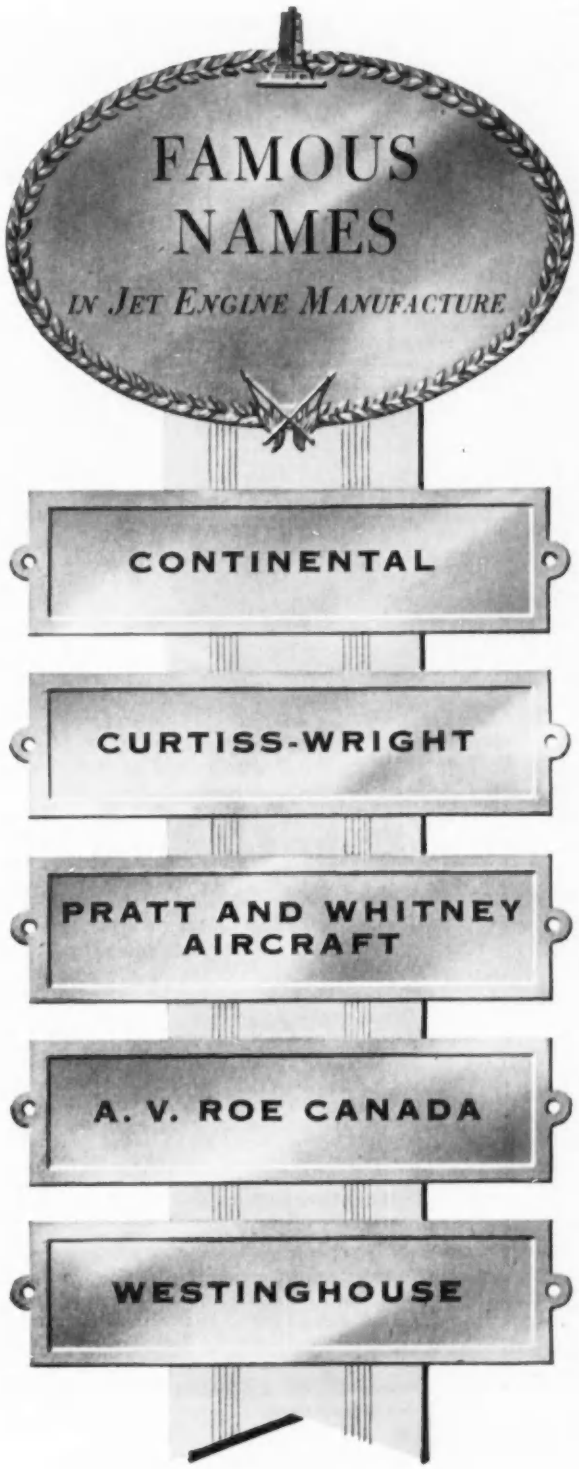
PLANTS—Niagara Falls, N. Y.; Graham, W. Va.; Cambridge, Ohio; Durango and Naturita, Colo.

RESEARCH CENTER—Cambridge, Ohio

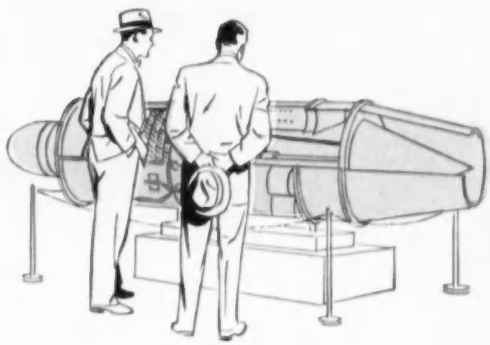
MINES—South America, Southern Rhodesia, Canada, U.S.A.

VANCORAM

Producers of alloys, metals and chemicals



.....all using Bendix ignition equipment!



The Scintilla Division of Bendix is proud that the list of users of their jet ignition equipment is veritably a "who's who" of world-famous engine builders.

We are perhaps even more gratified, however, that our association with famous names in engine manufacturing has extended over many years and has covered a wide diversity of ignition products.

This continuing association with the industry's leaders has been more than a source of pride to us. It has been a challenge that we strive constantly to meet, and we pledge our every resource and facility to continue to merit this acceptance as The Most Trusted Name in Ignition.

SCINTILLA DIVISION OF Bendix
SIDNEY, NEW YORK

Bendix

AVIATION PRODUCTS

Low and high tension ignition systems for piston, jet, turbo-jet engines and rocket motors . . . ignition analyzers . . . radio shielding harness and noise filters . . . switches . . . booster coils . . . electrical connectors.

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

FACTORY BRANCH OFFICES: 117 E. Providencia Ave., Burbank, Calif. • Stephenson Bldg., 6560 Cass Ave., Detroit 2, Mich. • 512 West Ave., Jenkintown, Pa. Brouwer Bldg., 176 W. Wisconsin Ave., Milwaukee, Wisc. • American Bldg., 4 S. Main St., Dayton 2, Ohio • 8401 Cedar Springs Rd., Dallas 19, Texas

Four-wheel-drive INTERNATIONALS provide new standards of efficiency and stamina for a wide variety of public utility jobs. Shown is an R-160 (4x4) with service-utility body, winch, and pole setting equipment.

MEET MISTER 4X4!

INTERNATIONAL four-wheel-drive trucks bring to public utility operators entirely new 4x4 performance and efficiency. These new four-wheel-drive trucks combine famous INTERNATIONAL stamina, long life, and operating economy with everything that's new and best in 4x4 design.

A two-speed transfer case affords eight forward and two reverse speeds, permitting movement of men, tools, and equipment over all kinds of terrain. *Two transmission power take-off openings allow operation of front-mounted winch, hydraulic hoist, or other auxiliary equipment. There is provision for mounting a third power take-off on the transfer case.*

INTERNATIONAL 4x4 trucks have everything it takes for tough public utility assignments, plus extra easy steering and handling, famous driver-designed Comfo-Vision cabs. Study the extra-value facts shown here, then get complete details from your INTERNATIONAL Dealer or Branch.

INTERNATIONAL HARVESTER COMPANY • CHICAGO

America's Finest Four-Wheel-Drive Trucks

Two chassis models: Model R-140 (4x4), 130- and 142-inch wheelbases, GVW rating, 11,000 pounds. Model R-160 (4x4), 154- and 172-inch wheelbases, GVW rating, 15,000 pounds.

All-truck power: Both models powered by famous INTERNATIONAL Silver Diamond engines.

Transmission: Sliding gear selective type. Four speeds forward, one reverse. Power take-off openings on right and left sides.

Transfer case: Two-speed declutching type, providing eight forward and two reverse speeds, with manual disengagement of front axle for normal two-wheel-drive operation. Three-position shifting —high, 1.00 to 1; low, 1.87 to 1; and neutral. Provision for mounting full torque power take-off at rear of input shaft.

International Harvester Builds **McCORMICK**® Farm Equipment and **FARMALL**® Tractors . . . Motor Trucks . . . Industrial Power . . . Refrigerators and Freezers

Better roads mean a better America

INTERNATIONAL® TRUCKS

"Standard of the Highway"

IN this cost-conscious era of close competition, there is a constant search for methods to reduce manufacturing costs. One way this is being accomplished by manufacturers of refrigeration equipment . . . is by making full use of the Microhoning process on vital functional surfaces of parts such as the bearing plate, crank case, main frame, front head casting, connecting rod, cast-iron housing, cylinders, pistons, and various small bushings.

What is Microhoning and how does it reduce manufacturing costs?

Microhoning is an abrading process that combines stock removal, geometric accuracy, size control and surface finish into one automatic operation. The rotating and reciprocating, automatically-expanding tool self-dresses its abrasives through its own motions, while faithfully duplicating the required surface finish.

The savings are in time, effort and equipment required to obtain comparable results by any combination of other means. Why not have a Micromatic Field Engineer discuss with you the advantages of Microhoning in your processing plans?

Write today for *Cross-Hatch* Vol. 6—No. 4

MICROMATIC HONE CORPORATION

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MICROMATIC HONE CORP. MICRO-MOLD MFG. DIV. Boston Post Road Guilford, Connecticut

MICROMATIC HONE CORP. 2205 Lee Street Evanston, Illinois

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MICROMATIC HONE LTD. 330 Grand River Avenue Brantford, Ontario, Canada

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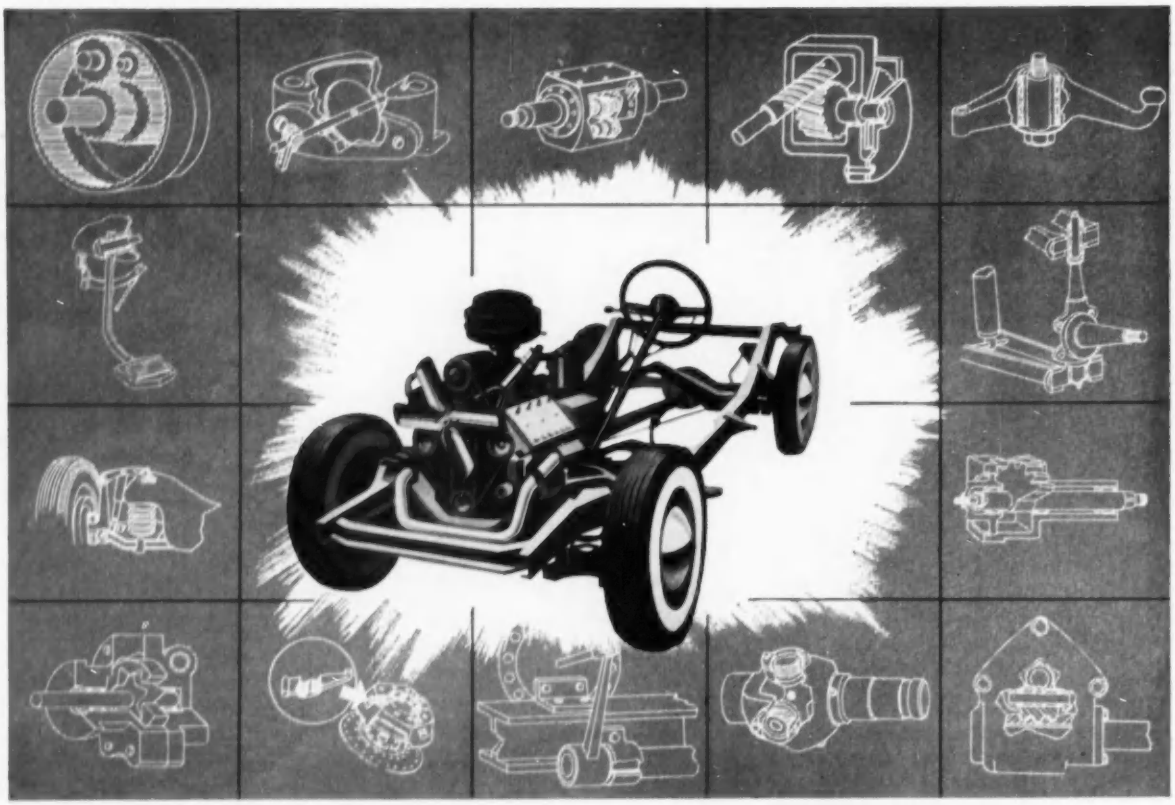
REPRESENTATIVES: Allied Northwest Machine Tool Corp., 103 S.W. Front Ave., Portland 4, Oregon • Mason Machine Tool Company, 415 So. Second East, Salt Lake City, Utah • Tidewater Supply Co., Charlotte 4, North Carolina Perine Machinery & Supply Co., 1921 First Ave., South, Seattle 4, Washington

REPRESENTATIVES IN ALL PRINCIPAL COUNTRIES



TORRINGTON Needle Bearings offer the Automotive Manufacturer these advantages

1. High capacity
2. Small size
3. Low cost
4. Ease of installation
5. Long service life

The automotive industry was one of the first to see the unique advantages of the Torrington Needle Bearing when it was introduced nearly twenty years ago. Today, leading manufacturers of automobiles, trucks and components have standardized on the Needle Bearing to such an extent that it is in use in almost every rotating or oscillating bearing application where compactness, high capacity and ease of installation are important.

The NEEDLE BEARING has been "Performance Proved" in these Major Applications

Universal joints · Governors · Steering gear rollers Steering knuckles · Steering idlers · Power steering Suspensions · Brake camshafts · Brake and clutch linkage pivots · Clutch throw out fingers · Transmissions · Hydraulic pumps · Window lifts *and many others.*

If some of these applications of the Needle Bearing are new to you, why not let our Engineering Department show you how they can improve the design and performance on your product? See your Torrington Bearing representative or write direct.

THE TORRINGTON COMPANY

Torrington, Conn. · South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

NOT A COLD IN THIS CARLOAD!

New Chevrolet Deluxe heater and defroster features illuminated panel with new slide-easy controls.

New Chevrolet heater-defroster maintains even car temperature ...provides panoramic defrosting.

Wind-swept, winter-whipped highway outside! But inside, the whole family rides in comfort . . . snug, warm, safe. Windows are clean and clear—temperatures are healthfully even throughout the car. That's because Harrison's Deluxe heater and defroster for the all-new Chevrolet has been *engineered for the job.* In building heaters and defrosters, it's engineering, research and production that count . . . and Harrison has been a leader for more than 40 years in the field of automotive heat transfer and control. That's why you'll find Harrison heaters and defrosters, as well as radiators, on Cadillac, Buick, Oldsmobile, Pontiac and Chevrolet. If you have a hot or cold problem, look to Harrison for the answer!

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N. Y.

HARRISON

TEMPERATURES MADE TO ORDER

DITZLER

DEPENDABLE *Automotive Finishes*

A Standard in the Automotive Industry Since 1902

Like the S. A. E. Journal, we, too, have served the amazing motorcar industry for more than half a century. • To have been privileged to serve it for so many years is a record in itself. To have improved our position continuously in this highly competitive field is a real accomplishment. • We could not have done it without the help of others in this great industry. To all of them we say "Thanks" . . . and especially to the S. A. E. Journal.

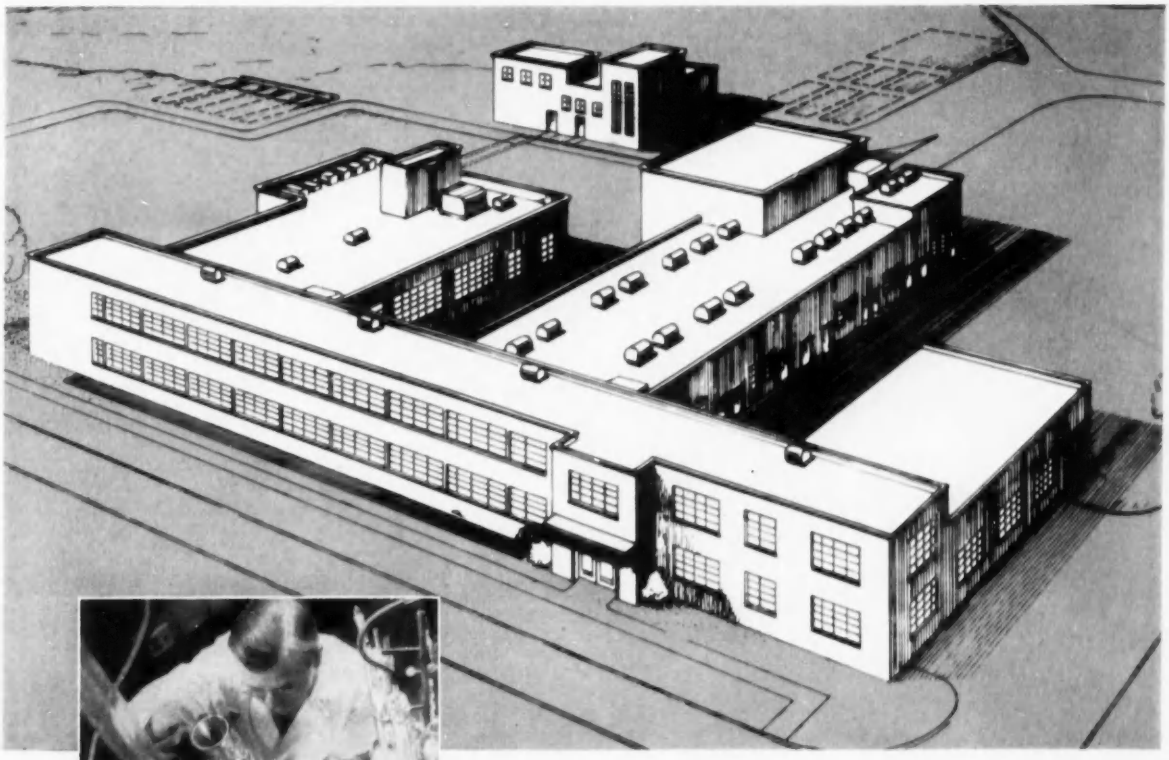
DITZLER COLOR DIVISION, PITTSBURGH PLATE GLASS COMPANY
Detroit 4, Michigan

DITZLER

PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS

PITTSBURGH PLATE GLASS COMPANY

IN CANADA: CANADIAN PITTSBURGH INDUSTRIES LIMITED



FUELS for tomorrow's engines

For many years Gulf has been a leader in petroleum research, with extensive modern laboratories at Harmarville, Pennsylvania, recognized as one of the leading industrial research establishments in the country.

Now in the process of construction, the new structure shown above will give Gulf one of the most advanced installations in the world for fuel and lubricant testing in internal combustion engines. It will provide enlarged space and special equipment designed to aid in the development of improved fuels for the engines of the future, both reciprocating and turbo designs.

In addition, facilities will be expanded for the development of tougher, better lubricants which will be required for tomorrow's engines. The main building will contain 24 engine test rooms, including three rooms where the temperature can be varied between −70° and 130°F. One of these will allow the testing of the largest trucks and buses now on the road.

GULF OIL CORPORATION
GULF REFINING COMPANY

GULF

Cadillac

Only 35—But He Has Earned It!

Used to be you didn't see a young man at the wheel of a Cadillac very often.

Most of the proud and happy people driving Cadillacs showed at least a little gray at the temples.

But things are changing. In fact, it isn't at all unusual any more for a man in his thirties to move up to the "car of cars."

There are two basic reasons for this.

In the first place, success is coming earlier now to a great group of young men than in years gone by.

Men are going into business and the professions with fine technical training which starts them off at levels they used to be years in attaining.

And, secondly, the news of Cadillac's remarkable economy is spreading far and wide.

A Cadillac owner, for instance, can keep and drive his car for almost any period of years he may elect—for its endurance is beyond all practical measurement.

Upkeep is remarkably low—and few cars of any size or price will run farther on a gallon of gasoline.

And when it comes to *purchase* price—well, there are twelve models of other American makes which actually cost *more* than the lowest-priced Cadillac.

Thus, it is small wonder that more and more people in a younger age bracket are making the move to Cadillac. It has become a logical and practical thing for them to do.

So if *you* are ready for a Cadillac—remember that *achievement*—and not age—is the criterion.

CADILLAC MOTOR CAR DIVISION—GENERAL MOTORS CORPORATION

Among the many unusual design features of Lockheed's YC-130 turbo-prop transport for personnel or cargo, is the Menasco-built landing gear, arranged in tandem to facilitate operation of this airplane from small fields or rough forward airstrips.

Menasco was first to deliver complete aircraft landing gear utilizing high heat treat steels with ultimate tensile strengths from 260,000-280,000 PSI, and 20% saving in critical weight. Comprehensive research by Menasco into *all* aspects of high heat treat was necessary for the production of the landing gear for the new Lockheed YC-130, an airplane whose tremendous load-carrying capacity requires rugged performance of its landing gear. Pioneering accomplishments like this improvement of existing basic materials is one of the reasons why leading aircraft designers constantly look to Menasco Manufacturing Company for advanced ideas, originality of design and progressive techniques in the production of better landing gear.

menasco manufacturing company

Specialists in Aircraft Landing Gear

805 SOUTH SAN FERNANDO BOULEVARD, BURBANK

First in DEVELOPMENT, QUALITY, DELIVERY & SERVICE

OLIVER PRESENTS THE SUPER 88

Today's most powerful Row Crop Tractor

Now more powerful than any other row crop tractor, the Super 88 has 49.81 max. h.p. on the drawbar.

It pulls bigger implements, handles heavier loads under tougher conditions and comes through with flying colors every time.

Tops in economy, too, the Super 88 set the record in recent nationally recognized tests. It has a new high in compression ratios—7.0:1—to squeeze extra power from every drop of fuel. Offers your choice of gasoline or diesel engine, whichever costs less to run.

"Hydra-lectric" control system raises and lowers implements and regulates depths at the touch of a lever. The Super 88 has the widest range of speeds in farming: five working speeds, plus one road speed, plus two reverse . . . and it has Oliver's famed Independently Controlled PTO.

Best news of all, the Super 88 makes all these advancements in tractor design available at a competitive market price.

The new 88 is one of the Oliver Super tractors—models 55, 66, 77, 88 and 99—developed to offer a standout value in each of five power classes.

The Oliver Corporation, 400 West Madison Street, Chicago 6, Illinois.

OLIVER

"FINEST IN FARM MACHINERY"

AUTOMOTIVE
Bumpers • Bumper Guards • Shock Absorbers
4-Way Seat Actuators • Torsional Vibration Dampers
Hand Brake Levers • Fender Shields • Air Cleaners
Tire Covers • Continental Type Tire Mounts
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AIRCRAFT
Shimmy Dampers • Flutter Dampers
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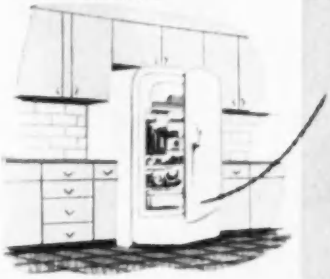
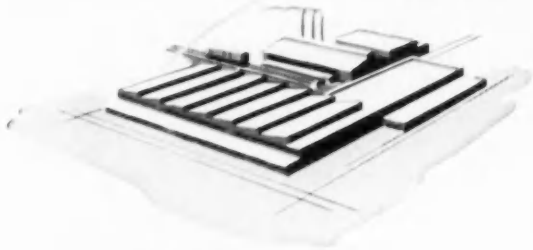
RAILROAD
Friction Snubbers
Shock Absorbers

Eight HOUDAILLE-HERSHEY MANUFACTURING DIVISIONS serve major U.S. Industries

REFRIGERATION
Evaporators
Condensers



AGRICULTURAL
Oil Purifiers
Air Cleaners



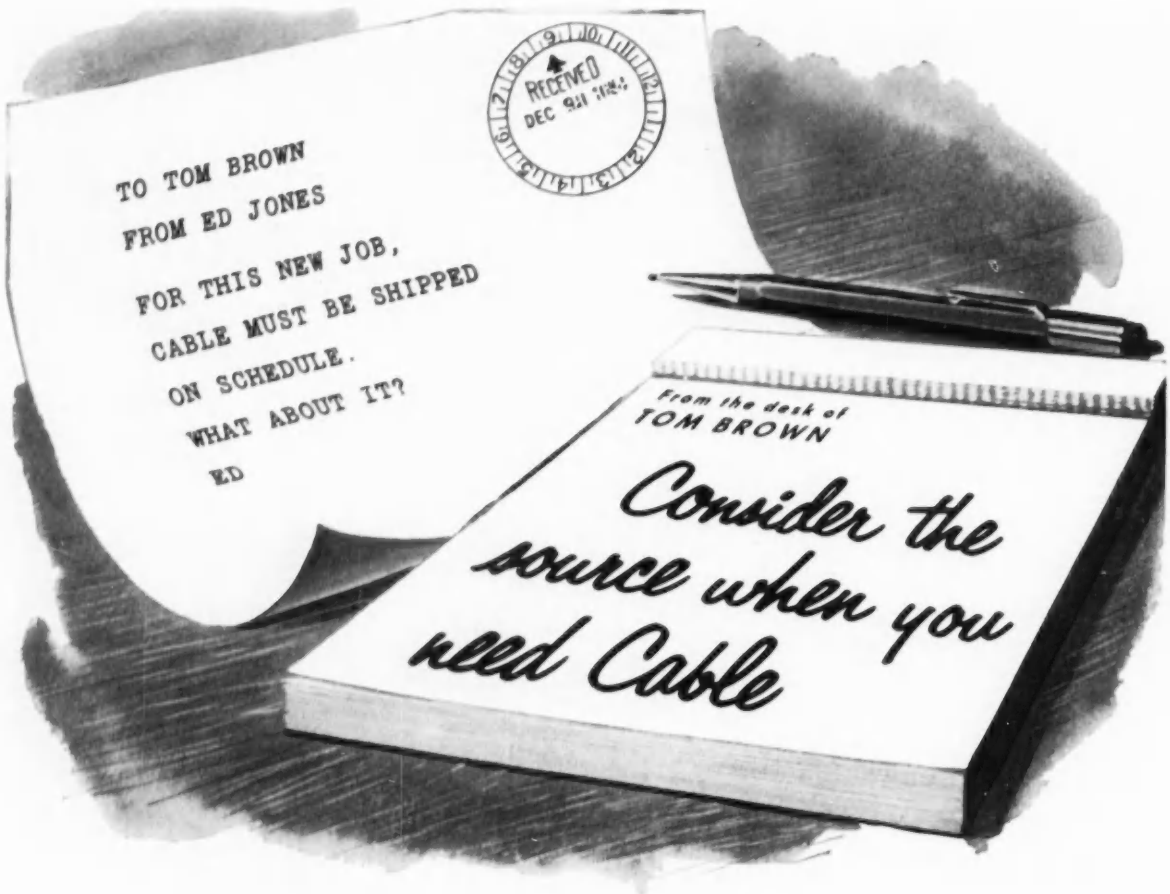
GENERAL INDUSTRY
Oil Purifiers • Clarifiers • Automatic Conveyors
Mobile Sump Cleaners • Magnetic Filters • Web-type Filters
Purivac Insulating Oil • Purifiers • Mobile Coolant Filters

DIESEL
Oil Purifiers
Torsional Vibration Dampers
Air Cleaners

Houdaille-Hershey Corporation

EXECUTIVE OFFICES
FISHER BUILDING • DETROIT 2, MICHIGAN

MANUFACTURING DIVISIONS ARE LOCATED IN
DETROIT • CHICAGO • NORTH CHICAGO • DECATUR, ILLINOIS • BUFFALO, NEW YORK
HUNTINGTON, WEST VIRGINIA • LEBANON, INDIANA • OSHAWA, ONTARIO, CANADA



Prompt, dependable delivery schedules are important to any manufacturer. And promptness is the natural result of Packard Electric's flexible, carefully regulated production schedules. Add to this the high quality of Packard cable that consistently meets or exceeds applicable specifications, and you have two of the many benefits you can enjoy through dealing with Packard Electric.

Consider Packard as a source

In addition to facilities sufficient to manufacture *daily* more than 7,000,000 feet of cable and more than 800,000 wiring assemblies, Packard Electric can offer you the services of its large engineering staff to help solve any cable problem. These benefits have often meant big savings for Packard customers. It is quite possible that they could be of equal value to you.

GM GENERAL MOTORS Packard

REG. U.S. PAT. OFF.

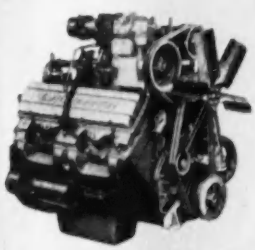
Packard Electric Division, General Motors, Warren, Ohio
Offices in Detroit, Chicago, and Oakland, California

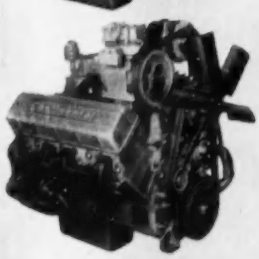
AVIATION, AUTOMOTIVE AND APPLIANCE WIRING

Congratulations Again!

Continental Motors was only three years old when the Society of Automotive Engineers was organized. This advertisement, published in The S.A.E. Journal for June 1930, was Continental Motors' salute to the S.A.E. on its Silver Anniversary.

Below are the two latest additions to the Continental Red Seal® line. Upper engine, Model V8603 Overhead Valve V8 (Gasoline), 240 h.p. Lower engine, Model VD8603 Cushioned® Power Diesel, 182 h.p. at 2800 r.p.m.





Once more, Continental Motors pays its respects to a great organization—an organization with aims and ideals closely akin to its own. In the 25-year period since that earlier salute, these two "gentlemen of experience" have broadened their operations, heightened their prestige. The start of its second half-century finds the S.A.E. teamed more closely than ever before with the industry of which Continental is a part—doing more than ever before in its 50-year history, not only to strengthen this nation, but to make daily life more modern, here and throughout the world.

POWER SPECIALISTS SINCE 1902

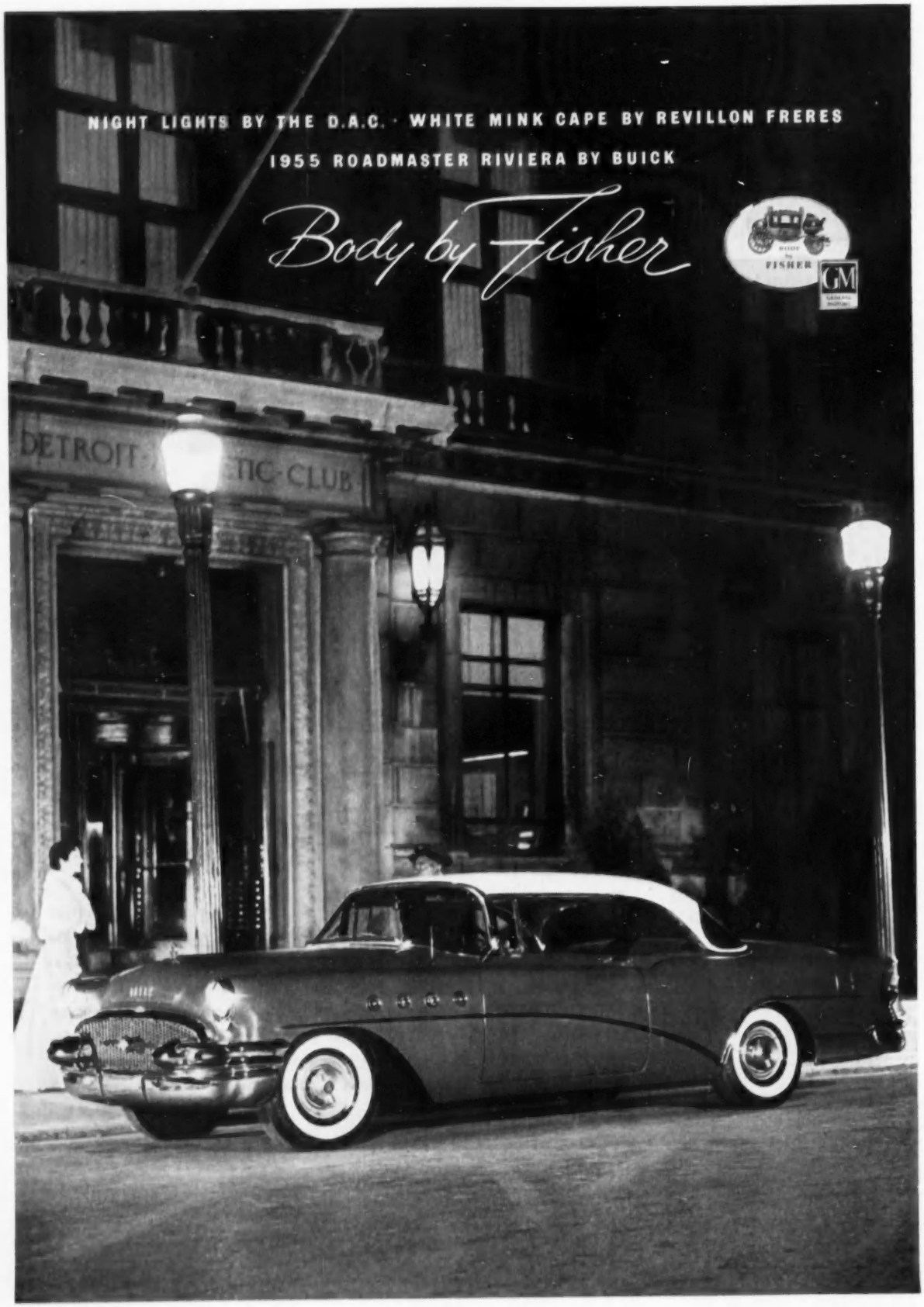
1905 S.A.E. GOLDEN ANNIVERSARY 1955

Continental Motors Corporation

MUSKEGON, MICHIGAN

CONTINENTAL MOTORS® Powerful as the Nation AMERICA'S STANDARD

6 EAST 45TH STREET, NEW YORK 17, NEW YORK • 6218 CEDAR SPRINGS ROAD, DALLAS 9, TEXAS • 3817 SOUTH SANTA FE AVENUE, LOS ANGELES 58, CALIFORNIA • 910 SOUTH BOSTON STREET, ROOM 1008, TULSA, OKLAHOMA • 1252 OAKLEIGH DRIVE, EAST POINT (ATLANTA) GEORGIA


NIGHT LIGHTS BY THE D.A.C. · WHITE MINK CAPE BY REVILLON FRERES
1955 ROADMASTER RIVIERA BY BUICK
Body by Fisher
Body by FISHER
GM
DETROIT
TIC CLUB

New Idea For | *Extending Lube Periods Reducing Grease Inventories*

STANDARD *Lithium Multi-Purpose Grease*

Waterloo-Cedar Falls Transit Company operates 48 units serving this Iowa metropolitan area. In September, 1953, seeking to increase time between lubrication jobs, they began using STANDARD Lithium Multi-Purpose Grease for all bus lubrication. Results since that date: not one lubricating failure or problem. In addition the company not only cut costs but reduced grease inventories. Now STANDARD Lithium Multi-Purpose Grease lubricates every spot on equipment needing lubrication, including wheel bearings, water pump, throw out bearings, generators, etc.

STANDARD Lithium Multi-Purpose Grease is water and heat resistant. It can be used to lubricate all types of bearings—ball, roller, plain and needle. It can be used in mechanical and hand operated dispensers. Using it eliminates stocking most special purpose greases, thus greatly reducing the possibility of costly mistakes in selecting greases, one of the biggest maintenance hazards.

Like to know more about STANDARD Lithium Multi-Purpose Grease? In the midwest, call your nearby Standard Oil Automotive engineer. He will be happy to help you. Or contact, Standard Oil Company, 910 South Michigan Avenue, Chicago 80, Illinois.

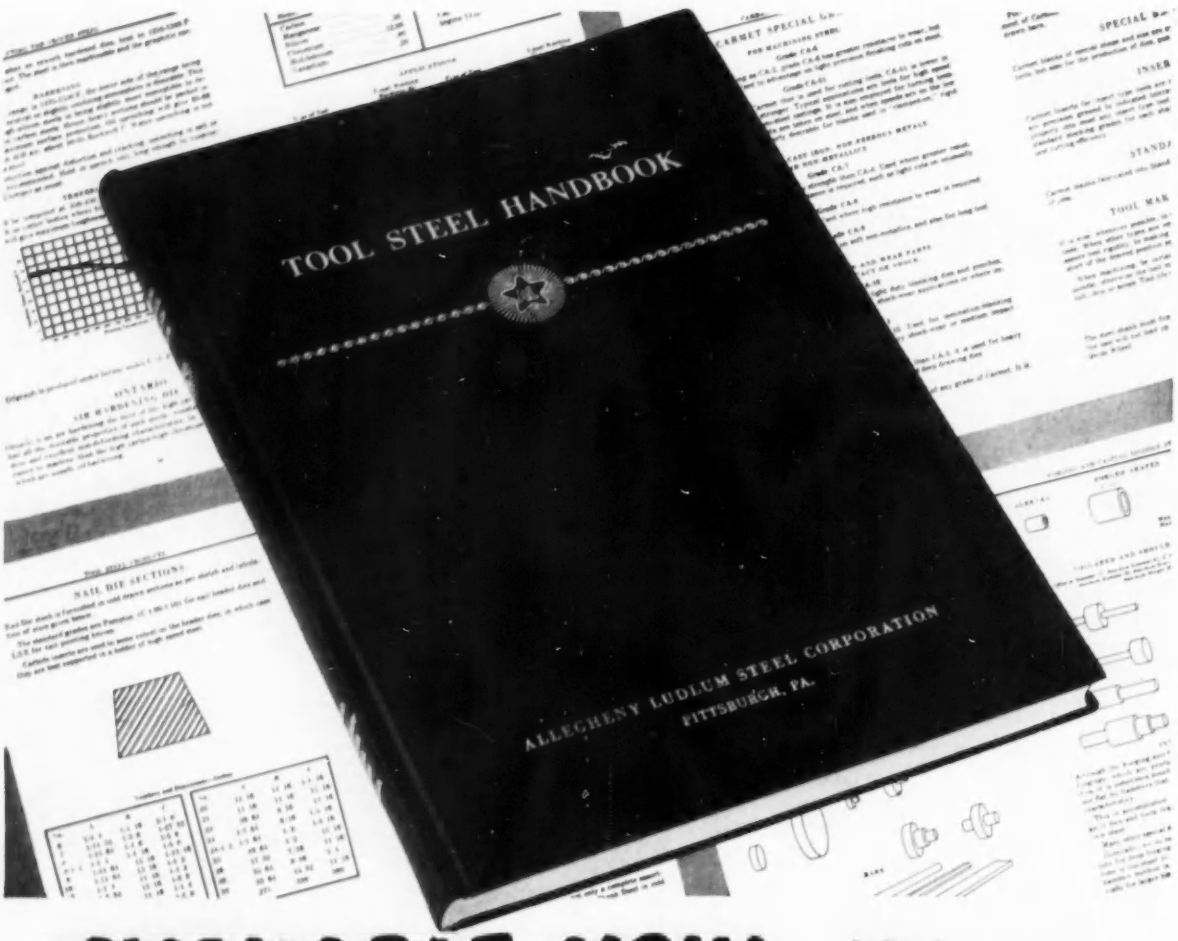
Waterloo-Cedar Falls Transit Co., Leon M. Gahwiller, Manager, and J. S. Duncan, Vice President and General Manager, talk over lubrication problems with Standard Automotive Engineer, Stanley L. Johnson. Discussions like this lead to savings on lubrication. Stan Johnson has been helping bus, truck and contractor fleet operators lick lubrication problems since he completed the Standard Oil Automotive Sales Engineering School. Stan is a graduate of Iowa State College, Ames, with B.S. in engineering. Customers have found this experience and training pay off for them.

Waterloo-Cedar Falls Transit Co. operates 48 bus units in this Iowa metropolitan area, uses STANDARD Lithium Multi-Purpose Grease for all lubrication on buses.

STANDARD

STANDARD OIL COMPANY

(Indiana)



AVAILABLE NOW—196 pages of Valuable Tool Steel Information

Another printing of our Tool Steel Handbook—one of the most comprehensive treatises of its kind ever offered by a tool steel producer—is just off the presses. In addition to a relatively complete picture of Allegheny Ludlum Tool Steels, their properties, applications and the forms in which they are available, this 196-page case-bound book presents an extensive discussion of heat treating and handling techniques as well as a complete set of weight tables and other useful reference material.

Your copy of the Tool Steel Handbook will be sent—*without charge*—upon request. Our only stipulation: please make your request upon your company letterhead. ● Write to *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pennsylvania.*

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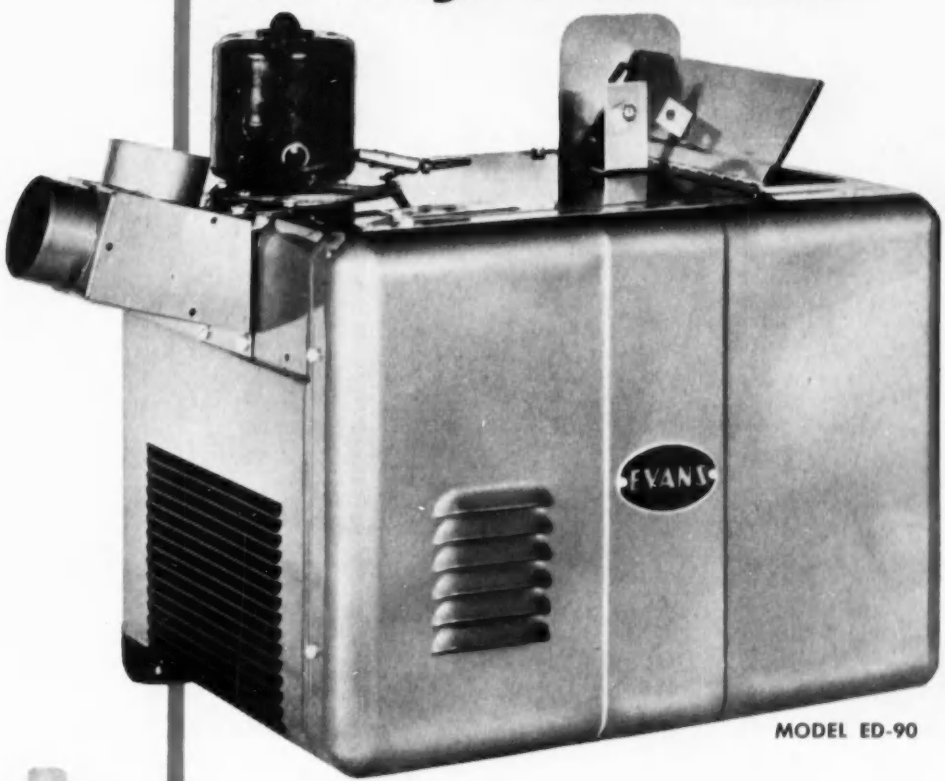
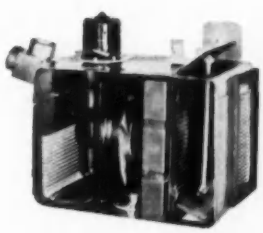
a new heater defroster

specially designed by EVANS for large truck cabs



MODEL ED-90



Removing front cover exposes all elements for easy servicing. Note the exclusive Evanair 9" Die-cast fan, the interlocked dampers for mixing recirculated and fresh air, the extra thick 2" core, the built-in high pressure blower with extra large motor and the over-all heavy duty construction.

- 100% fresh air or mixed with recirculated air as driver desires
- Powerful built-in pressure type defroster blower 72.2 CFM of hot air at windshield
- Controlled summer comfort, 100% fresh air with water shut off
- Balanced heat distribution to cab floor, driver and helper
- Pressurized heating and ventilating when set for all fresh air
- Plus all these Evans standard features: Distinctive Styling, Compact Design, Modern Appearance, Built-in Durability, High Efficiency, Engineered-to-match motors, fans and cores, Easily Accessible Components, Full-Year (or 50,000 mile) Warranty.

For further information on Evans heaters or expert engineering advice on any truck or bus heating and ventilating problem, write Evans Products Company, Dept. Z-2, Plymouth, Michigan.

EVANS — *BALANCED HEATING & VENTILATING SYSTEMS FOR EVERY TRUCK AND BUS*

REGIONAL REPRESENTATIVES: CLEVELAND, FRANK A. CHASE • CHICAGO, R. A. LENNOX CO., INC. • DETROIT, CHAS F. MURRAY SALES CO. • ALLENTOWN, PA., P. R. WEIDNER

FLEXLOC AT WORK

MORE AND MORE FLEXLOC LOCKNUTS are being used on applications where dependable locking is essential to the operation of the equipment and the safety of the operator. This bundling chain with automatic lock provides positive grip and safe, sure bundle handling.

Two FLEXLOC Self-Locking Nuts hold this assembly together. Once the locking threads are fully engaged, the nuts won't work loose, regardless of the conditions under which they are used.

FLEXLOC one-piece, all-metal nuts are available in a full range of sizes in any quantity. Standard FLEXLOCS are stocked by leading industrial distributors everywhere. Write for Bulletin 866 and samples. STANDARD PRESSED STEEL CO., Jenkintown 55, Pa.

DO YOU KNOW? Standard FLEXLOCS smooth off rough bolt threads. The locking threads on all-metal FLEXLOCS are not chewed up when used on rough bolts.

Standard FLEXLOCS lock securely on bolts varying in diameter tolerances. The all-metal, resilient locking sections of the nut accommodate themselves to the diameter tolerances.

Standard FLEXLOCS are one piece, all metal. They are not affected by temperatures to 550°F. Nuts lacking these features have a more restricted temperature range.

Standard FLEXLOCS lock securely—stopped or seated—when 1½ threads of a standard bolt are past the top of the nut.

Standard FLEXLOCS are not affected by moisture, oil, dirt or grit. They lock efficiently under all conditions, regardless of the vibration encountered.

FLEXLOC®
LOCKNUT DIVISION
SPS
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Another U. S. Engineered Rubber Product serving the automotive industry

It's here!

Designers can now specify noiseless, positive power transmission with the U. S. Rubber

PowerGrip TIMING Belt

This revolutionary belt gives the automotive designer new opportunities! U. S. PowerGrip gives *positive* power transmission. It operates on fixed centers. **No lubrication is needed.** But if lubrication is encountered from other machine parts, we provide belts that are oil-resistant—even to hot oil. Just a few of its exciting possibilities are:

1 – Extreme low stretch, great flexibility in the range of center distances make the belt ideal for camshaft drives. *No noise—no lubrication.*

2 – PowerGrip's higher load capacities, its length range (from a few inches to many feet) and its width range (⅛" to 15") makes it ideal for use on window regulators and governors, accessories and special equipment.

High efficiency, small pulley diameters, fixed centers and a single belt instead of a multiple drive make PowerGrip a natural for dozens of automotive applications. United States Rubber Company engineers will gladly work with any automotive manufacturer who is interested in the great advantages of U. S. PowerGrip. Just phone us at Trinity 4-3500, Detroit, and ask for Mechanical Goods Division, or write address below.

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250 HP Chrysler New Yorker Deluxe St. Regis

America's most smartly different car

CHRYSLER FOR 1955

WITH THE NEW 100-MILLION-DOLLAR LOOK

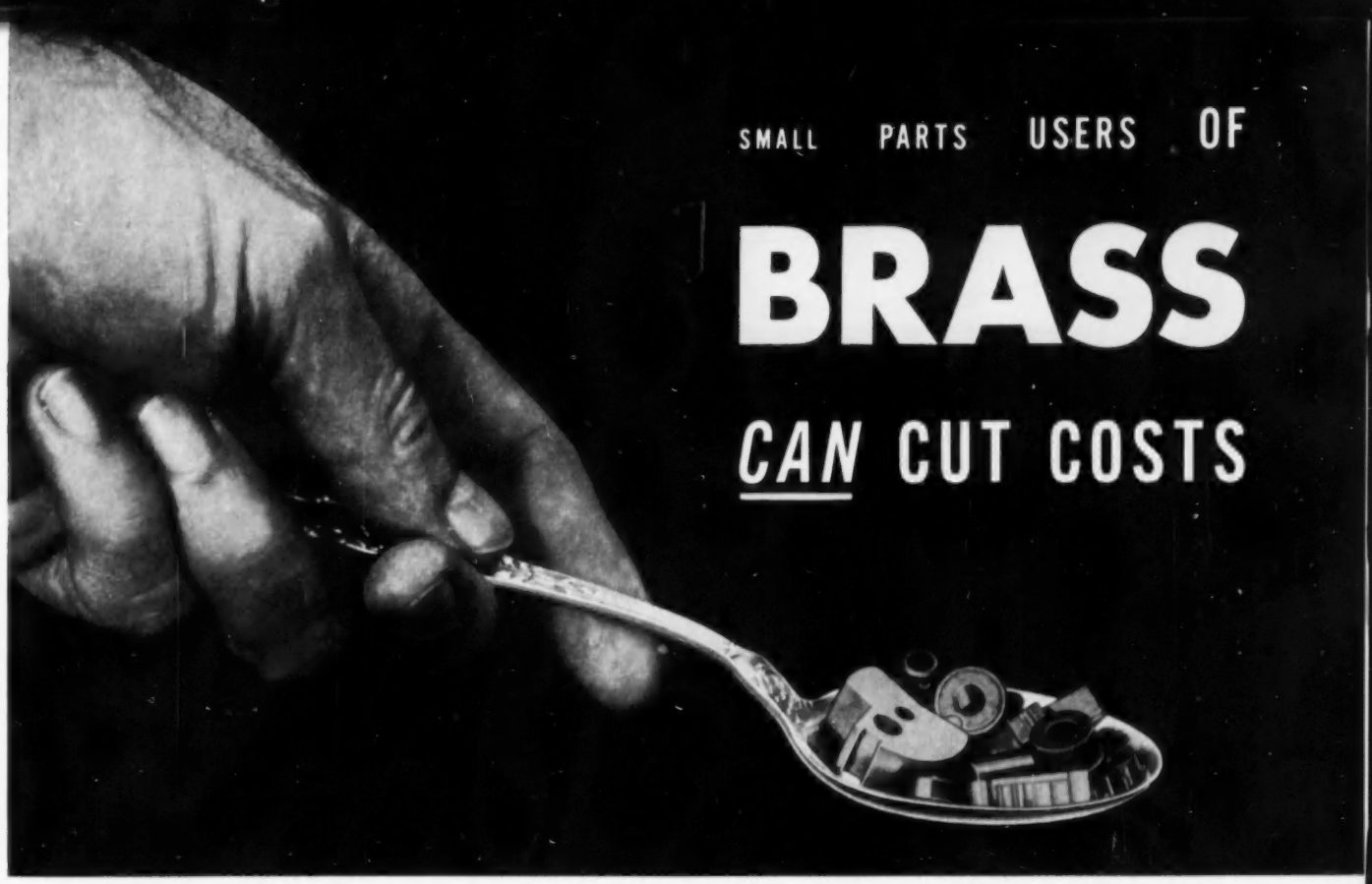
IT'S HAPPENED! . . . a wholly *new* direction in automotive styling for all cars to follow. Created by Chrysler: America's top performer and first in the next generation of motor cars!

Come see it. Everything here is completely new . . . dramatically different. It's the car with the new 100-Million-Dollar Look . . . and when you own and drive it you'll *feel* like a hundred million dollars!

New front end . . . you can spot it a mile away. "New Horizon" Super-Scenic sweptback windshield that allows *maximum* vision. New Twin-Tower tail lights that say "Stop!" with greatest authority. New sweeping silhouette – longer and *lower* than other big cars. New PowerFlite Range-Selector on the dash. New luxury interiors, richer than anything you've ever seen before!

Come drive it! *Every Chrysler is now a V-8* – with engines up to 250 H.P.: most powerful type in the world. Famous Chrysler engineering also brings you PowerFlite, *most automatic* of all no-clutch transmissions . . . Chrysler Full-Time Power Steering . . . Power Brakes . . . and new tubeless tires. Stop in today and see for yourself why *the power of leadership is yours in a Chrysler!*

See Your Chrysler-Plymouth Dealer



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BY DESIGNING PARTS TO BE *PRESSED FROM BRASS POWDER*

The tens of millions of powder metallurgy brass parts in use today are evidence that alert engineers can design this proven material into many products which previously called for a brass casting, stamping, or machined part. In designing parts of brass—as in any other design problem—price is rarely the first factor to consider—but almost always the *second*. It's QUALITY you consider first. Will the part meet your requirements for strength, density, color, accuracy of size . . . meet these requirements uniformly by the tens of thousands or by the millions? Bound Brook, pioneer in powder metallurgy can answer your quality questions . . . then, if your requirements are for volume . . . can usually quote a price that means a substantial saving . . . and can make delivery, as promised, to keep your production line moving. For authoritative answers on your questions about powdered brass, bronze, or iron parts . . . or bronze or iron bearings . . . write or wire Bound Brook direct or telephone your nearby Bound Brook man.

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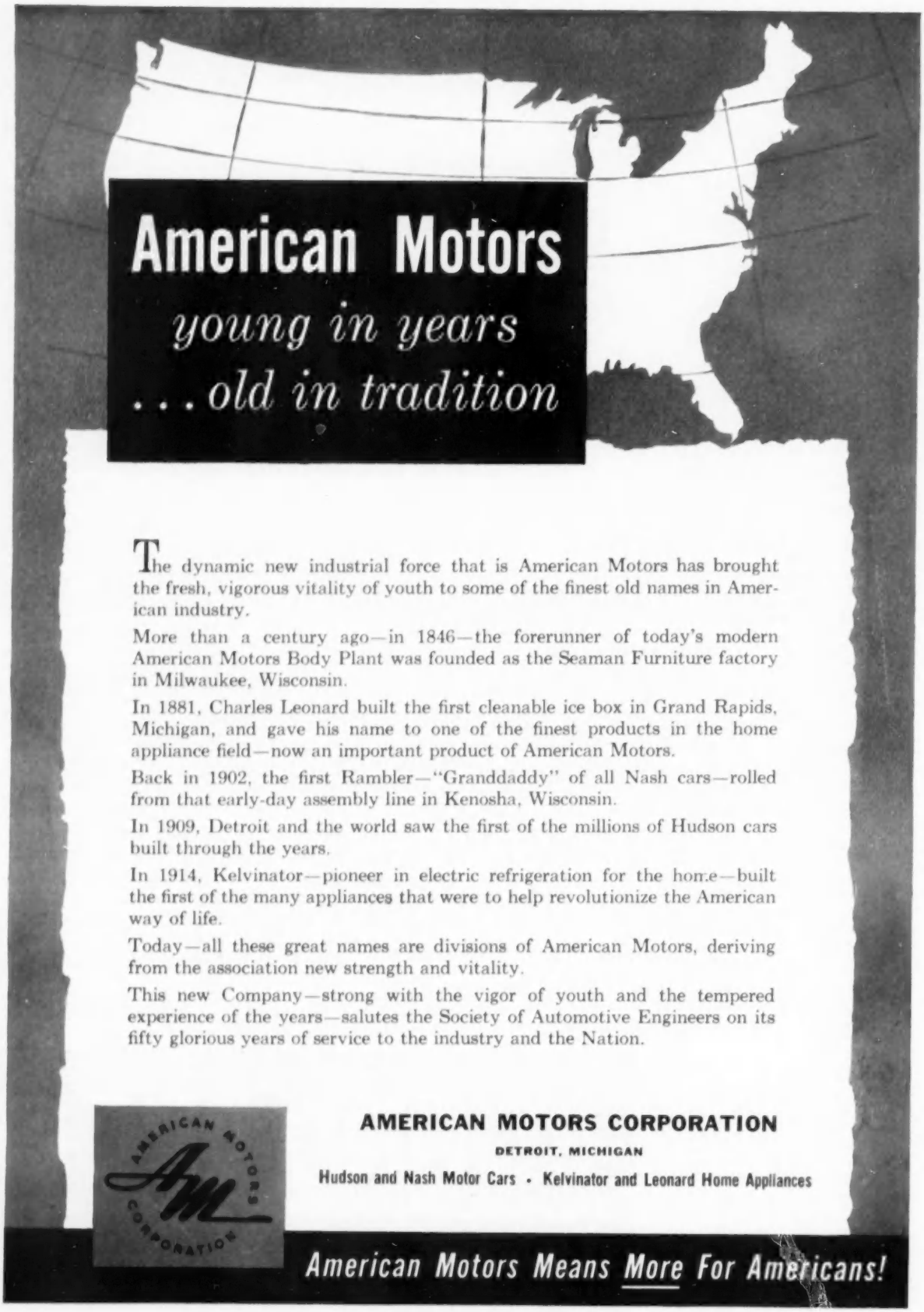


The dynamic new industrial force that is American Motors has brought the fresh, vigorous vitality of youth to some of the finest old names in American industry.

More than a century ago—in 1846—the forerunner of today's modern American Motors Body Plant was founded as the Seaman Furniture factory in Milwaukee, Wisconsin.

In 1881, Charles Leonard built the first cleanable ice box in Grand Rapids, Michigan, and gave his name to one of the finest products in the home appliance field—now an important product of American Motors.

Back in 1902, the first Rambler—"Granddaddy" of all Nash cars—rolled from that early-day assembly line in Kenosha, Wisconsin.

In 1909, Detroit and the world saw the first of the millions of Hudson cars built through the years.

In 1914, Kelvinator—pioneer in electric refrigeration for the home—built the first of the many appliances that were to help revolutionize the American way of life.

Today—all these great names are divisions of American Motors, deriving from the association new strength and vitality.

This new Company—strong with the vigor of youth and the tempered experience of the years—salutes the Society of Automotive Engineers on its fifty glorious years of service to the industry and the Nation.

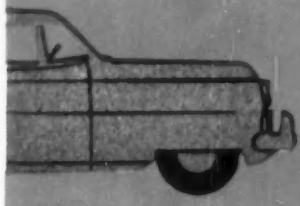
AMERICAN MOTORS CORPORATION

DETROIT, MICHIGAN

Hudson and Nash Motor Cars • Kelvinator and Leonard Home Appliances

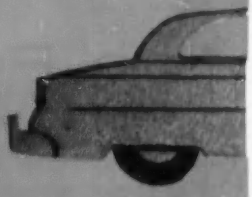
American Motors Means More For Americans!

more cars and trucks



are factory-equipped

with FRAM



than any other make

OVER 150 LEADING MANUFACTURERS SPECIFY FRAM AS STANDARD EQUIPMENT

Year after year, FRAM leads the industry in design, development and production of finer filtration systems. This FRAM leadership can help solve your problem in oil, air, fuel or water filtration. FRAM engineering facilities, including the FRAM Dust Tunnel at Dexter, Michigan, are at your disposal.

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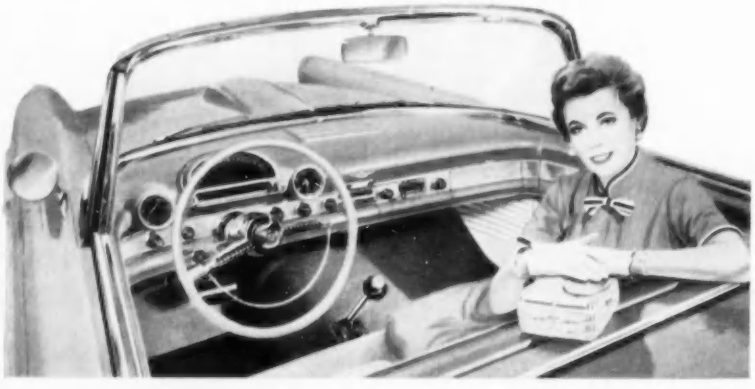
An engineering success story—

the Ford THUNDERBIRD

From Ford's Styling and Engineering Departments has come a totally new kind of automobile . . . the Ford Thunderbird . . . a personal car of distinction.

For the first time, high performance and exceptional roadability have been combined with day-long, any-weather comfort. Here is an engineering achievement equalled only by the styling originality that has made the Thunderbird the center of attraction wherever it goes.



Nestled under the long, low hood is a 198-h.p. Thunderbird Special V-8 with its four-barrel carburetor, an 8.5 to 1 compression ratio and twin exhausts.

The body is all steel and two tops are available . . . a solid top that is easily lifted on and off, and a convertible top that stows away completely out of sight behind the foam-rubber seat.

A four-way power seat and telescoping steering column let the driver select his own just-right driving position. And, with new Speed-Trigger Fordomatic, there's an automatic low gear for flashing getaway and an intermediate gear for normal starts, all without touching the shift lever. Conventional and Overdrive transmissions are also available, as are power brakes, power steering, and power window lifts.

The stylists and engineers who created the Thunderbird can be proud of their achievement. We salute them and all automotive engineers whose combined efforts have contributed so greatly to automotive progress during the past 50 years.

FORD Division of FORD MOTOR COMPANY

"I ALWAYS HAVE AIR TO SPARE... I've Got a MIDLAND Compressor!"

"A long grade like that's a cinch with a Midland compressor working for you . . . Shucks—I always have plenty of air for any kind of emergency—long hills or the steady stop and go of city traffic jams. My Midland compressor keeps my air tanks full *all* the time . . . That's why my boss has standardized on Midland air brakes and compressors all the way through his fleet. He's smart!"

Yes, it *is* smart to insist on a Midland Compressor, for Midland gives you these big advantages:

Greatest Efficiency—Due to patented automatic inlet valves built into cylinder head.

Minimum Oil Consumption—Due to lack of high vacuum on suction stroke.

Cooler Operation—Because inlet valves let atmospheric air circulate through compressor when idling, practically eliminating carbon.

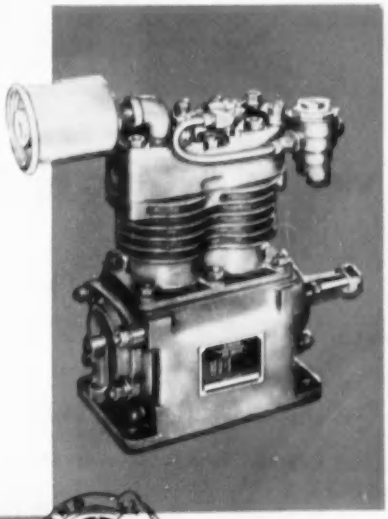
Integral Governor — Governor mounted on compressor simplifies installation.

Less Weight—A very important factor for today's operators.

Reduced Maintenance—Lack of compressor oil pumping greatly reduces maintenance due to elimination of oil and varnish deposits throughout the entire air brake system.

* * *

For complete details, see your nearest Midland dealer—or write factory direct.



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Those Who Know Power Brakes

CHOOSE MIDLAND!

ONLY
OLDSMOBILE
HAS

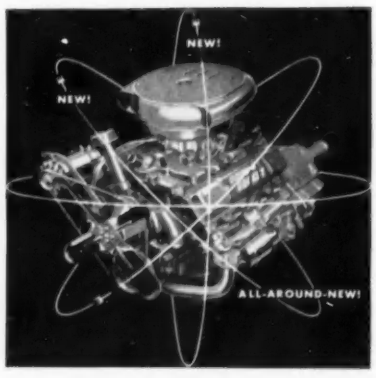
. . . That "Go-Ahead" Look!

Oldsmobile Super "88" Holiday Coupé. A General Motors Value.

with "Rocket" 202 Power to Match!

Stepping out in style! That's Oldsmobile for '55! Once again Oldsmobile has gone far forward with an all-new concept of motor car glamor. It's the bold "Go-Ahead" look—a sweet symphony of "flying color" styling—lively, low-level lines. Original beauty is everywhere—and there's "Rocket" power to spare! Without question, 1955 is another great Oldsmobile year! Oldsmobile is rocketing out ahead . . . *to stay ahead!*

All-new "Rocket" 202 Engine features 8.5 to 1 compression ratio, 202 horsepower, new higher torque, new high-lift camshaft, new power-contoured combustion chambers.



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DIVISION OF GENERAL MOTORS CORPORATION • LANSING, MICHIGAN

"The red key? It adjusts the power in my car battery. Starts my engine fast in Winter, and gives me a cool-running battery in Summer. Same battery's used by police, cab drivers, doctors and salesmen. It's already lasted twice as long as my old battery; and besides, it's done a better job the whole year 'round".

Super Willard Weathermaster with Key-Operated Climate Control adjusts electrolyte level at the turn of a key...increases winter starting power... increases hot weather service life. Metalex grids provide 151% more protection against overcharging, the No. 1 battery killer. Safety-Fill construction prevents overfilling, which can cause acid spray and dangerous corrosion.

You can always depend on Willard to be first with the best

1902 Sparking batteries for ignition systems
1906 One-piece rubber containers
1908 Electric lights for automobiles
1909 Batteries for electric starters
1913 The Battery Service Station
1917 Thread-rubber insulation; non-spill aircraft batteries
1921 Radio storage batteries
1923 Charged Bone-Dry batteries
1937 Electrical Check
1949 Metalex grids
1953 Key-Operated Climate Control
1954 Outboard Starting Power Pack

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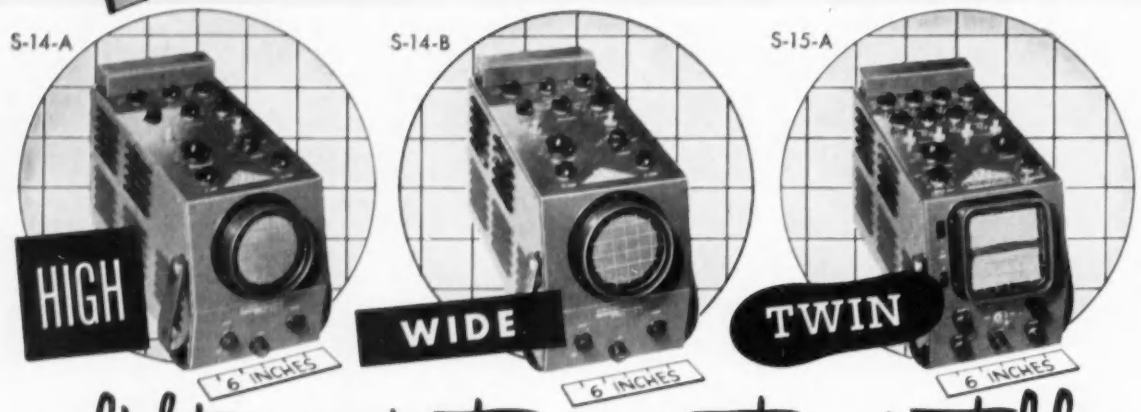
AGAIN IN 1955—SPECIFIED AS ORIGINAL EQUIPMENT BY MORE MANUFACTURERS THAN ANY OTHER BATTERY

Waterman POCKETSCOPE

The Pocket-Size Oscilloscope

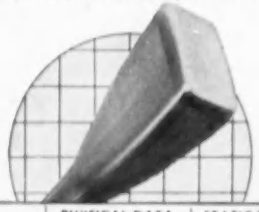


...light...compact...accurate...portable

Featuring small size, light weight and outstanding performance the HIGH, WIDE and TWIN POCKETSCOPES have become the "triple threat" of the oscilloscope field. Their incomparable versatility, reliability and accuracy have skyrocketed this team of truly portable instruments into unparalleled demand. Each oscilloscope features DC coupled amplifiers in both vertical and horizontal channels.

HIGH

The S-14-A HI-GAIN POCKETSCOPE provides the optimum in oscilloscope flexibility for analysis of low-level electrical impulses. Extremely light weight (12¾ lbs.), compact in size (12 x 5¾ x 7 in.), dependable and accurate in performance. Vertical and horizontal channels: 10mv rms/inch with response within 2DB from DC to 200 KC and pulse rise of 1.8 μs . . . non-frequency discriminating attenuators and gain controls with internal calibration of trace amplitude . . . repetitive or trigger time base with linearization from ½ cycle to 50 KC with ± sync or trigger.



WIDE

The S-14-B WIDE BAND POCKETSCOPE is ideal for investigations of transient signals, DC signals, aperiodic pulses or recurrent waveforms. Vertical channel: 50 mv rms/in. within —2DB from DC to 700 KC . . . pulse rise time of 0.35 μs. Horizontal channel: 0.15v rms/in. within —2DB from DC to 200 KC . . . pulse rise of 1.8 μs. Attenuators and gain controls are non-frequency discriminating . . . trace amplitude calibration . . . repetitive or triggered time base from ½ cycle to 50 KC . . . ± sync or trigger . . . trace expansion, filter graph screen and many other features . . . 14 lbs. . . . 12 x 6 x 7 inches.

TWIN

The S-15-A POCKETSCOPE is a portable, twin tube, high sensitivity oscilloscope with two independent vertical as well as horizontal channels. It is indispensable for investigation of electronic circuits in industry, school and laboratory. Vertical channels 10 mv rms/in. with response within—2DB from DC to 200 KC and pulse rise time of 1.8 μs . . . horizontal channels 1v rms/in. within —2DB from DC to 150 KC . . . non-frequency discriminating controls . . . internal signal amplitude calibration . . . linear time base from ½ cycle to 50 KC, triggered or repetitive, for both horizontal channels.

S-11-A

The S-11-A INDUSTRIAL POCKETSCOPE is a small, compact (5x7x11 inches), and lightweight (8¾ lbs.) instrument for observing electrical circuit phenomena. The flexibility of the POCKETSCOPE permits its use for AC measurements as well as for DC. The vertical and horizontal amplifiers are capable of reproducing within —2DB from DC to 200 KC with a sensitivity of 0.1v rms/in. . . . repetitive time base from 3 cycles to 50 KC continuously variable throughout its range . . . variations of input impedance, line voltage or controls do not "bounce" the signal—the scope stabilizes immediately.

RAYONIC CATHODE RAY TUBES BY WATERMAN

TUBE	PHYSICAL DATA		STATIC VOLTAGE		DEFLECTION*		LIGHT OUTPUT**
	FACE	LENGTH	A3	A2	VERT	HOR	
3JP1	3"	10"	3000	1500	111	150	352
3MP1	3"	8"		750	99	104	33
3RP1	3"	9.12"		1000	61	86	44
3SP1	1.5x3"	9.12"		1000	61	86	44
3XP1	1.5x3"	8.875"		2000	33	80	218

The basic properties of the cathode ray tube that concern the designer or the user are: deflection sensitivity, unit line brightness, line width, static voltage requirements and physical size. A comparison between cathode ray tubes manufactured by Waterman Products Company is shown in the table adjoining. These tubes are available in P1, P2, P7 and P11 phosphors. 3JP1, 3JP7, 3SP1 and 3XP1 are available as JAN tubes.

*Deflection in volts per inch.

** *Light output of an element of a raster line (one mm long and not exceeding .65 mm in width) in microlumens.*

Write for your complimentary copy of "POCKETSCOOP" • Official Waterman publication.

PULSESCOPE by Waterman

The Oscilloscope that Portrays the Pulse

Classic Examples of Precision Engineering...

The PULSESCOPES are cathode ray tube oscilloscopes that portray the attributes of the pulse: shape, amplitude, duration and time displacement. All PULSESCOPES have internally generated markers with the basic difference that in the SAR PULSESCOPE the markers initiate the sweep while in the others the sweep starts the markers.

BROAD

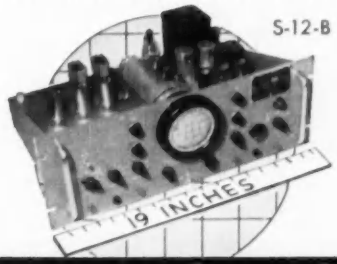
The S-6-A BROAD BAND Scope is a PULSESCOPE in performance, POCKETSCOPE in size. The instrument measures DC as well as AC signals. Unique DC calibration methods permit rapid measurements of either positive or negative, AC or DC signals. Vertical amplifier sensitivity of 0.2v rms/inch, and response to 5 mc within 3DB . . . pulse rise time of 0.1 μs . . . internal markers from 1 to 1000 μs . . . repetitive or trigger sweep from 5 cycles to 500 KC with 5X sweep expansion . . . sweep, marker and DC calibrating voltage available externally. Size 8½ x 6¾ x 13¾ in. Weight 22 lbs. Operates from 50 to 400 cycles at 115 volts AC.

LAB

The S-5-A LAB PULSESCOPE is a JANized (Gov't Model No. OS-26) portable, AC, wide band-pass, laboratory oscilloscope ideal for pulse as well as general purpose measurements. Internal delay of 0.55 μs permits observation of pulse leading edge. Includes precision amplitude calibration, 10X sweep expansion, internal trace intensity time markers, internal trigger generators and many other features. Video amplifier 0.1v p to p/inch . . . pulse rise time of .035 μs or response to 11 mc. 1.25 to 125,000 μs triggered or repetitive sweep . . . internally generated markers from 0.2 to 500 μs . . . trigger generator from 50 to 5000 pps. for internal and external triggering. Operates from 50 to 400 cycles at 115 volts AC.

SAR

The S-4-C SAR PULSESCOPE is a JANized (Gov't Model No. OS-4) portable instrument (31.5 lbs.) for precision pulse measurements for radar, TV and all electronic measurements. Portrays all attributes of the pulse . . . internal crystal controlled markers of 10 and 50 μs available for self-calibration . . . in R operation a small segment of the A sweep is expandable for detailed observation with a direct-reading calibrated dial accurate to 0.1%. Video amplifier band-pass up to 11 mc . . . optional video delay 0.55 μs . . . pulse rise and fall time better than 0.07 μs . . . R pedestal (sweep) 2.4 to 24 μs . . . video sensitivity of 0.5v. p to p/inch. Easily convertible from μs to yards. Operates from 50 to 400 cycles at 115 volts AC.



RAKSCOPE

Because the panel is only 7" high and fits any standard rack, the S-12-B RAKSCOPE admirably fills the need for a small oscilloscope of wide versatility. With all the features of the S-11-A POCKETSCOPE, the RAKSCOPE is JANized (Gov't Model No. OS-11), and has many additional advantages; the sweep, from 5 cycles to 50 KC, is either repetitive or triggered . . . vertical and horizontal amplifiers are 50 mv rms/inch with band-pass from 0 to 200 KC . . . special phasing circuitry for frequency comparison.

WATERMAN PRODUCTS CO., INC.

WATERMAN PRODUCTS

PHILADELPHIA 25, PENNA., U.S.A.

CABLE ADDRESS, POKETSCOPE, PHILA.

Manufacturers of POCKETSCOPES® • RAKSCOPES® • PULSESCOPES® and RAYONIC® TUBES

...in seconds **Start to Go at Forty Below**

with new AMPCO-SINCLAIR ENGINE STARTER

The AMPCO-SINCLAIR ENGINE STARTER represents an entirely new approach to effective starting fluid utilization. In diesel and gasoline engines of up to 1,000 cu. in. displacement (adjustable for larger engines), it works automatically in injecting the right amount of starting fluid at the proper rate of fluid flow. It eliminates the "human element"—provides fast, positive starting even by inexperienced operators!

IMPORTANT TECHNICAL FEATURES—

- Completely automatic metering device.
- A closed pressurized circuit which eliminates fumes and fire hazards.
- Utilization of aerosol principle as opposed to solid starting fluid injection.
- Designed to give a diminishing starting fluid/air rate after starting to sustain combustion.
- Designed to receive a sealed can of starting fluid to eliminate pouring.
- Rugged construction with a minimum of moving parts for simplicity.
- Controls large enough for manipulation with gloved hands.

ONLY THE AMPCO-SINCLAIR ENGINE STARTER PROVIDES—

- Positive starts at temperatures as low as −40°F.
- Prevention of harmful detonation through automatic metering.
- Foolproof operation even with inexperienced operators.
- Complete safety.
- Up to 60 individual starts (at an average of less than 5¢ per start) with a 10-oz. can of SINCLAIR STARTING FLUID.

For information, write

SINCLAIR REFINING COMPANY
Technical Service Division
600 Fifth Avenue, New York 20, N.Y.

AUTOMOTIVE AND MARINE PRODUCTS CORPORATION
87 Harvard Avenue
Boston 34, Mass.

Only a professional can fathom these sensations

FOR folks who buy cars by eye, by ear, and by the seat of their pants—every new Buick offers an abundance of all the desired sensations.

But only a professional can perceive the engineering that underlies these sparkling surface sensations.

Only a professional, for example, can fathom the degree of talent and care it took to clothe this big and rangy Buick in lines that blend function with beauty.

Only a professional can properly appraise the dozens of detailed advances that make the Buick V8 engine sturdier, more compact, more efficient—livelier to throttle touch after miles of high-compression performance.

Only a professional can fully appreciate the resourceful refinement of a principle exemplified by Variable Pitch Dynaflow*—the one transmission combining breakaway performance, fuel saving, and full-range smoothness.

And who but a professional can understand why every Buick rides more comfortably, handles more easily?

That's why there's such solid satisfaction in driving a Buick. Because all its attractions—including close-figured cost—are based on engineering the toughest-minded professional can approve.

So why not begin fathoming all these sensations yourself, in the new Buick model best suited to your purpose?

**Dynaflow Drive is standard on ROADMASTER, optional at extra cost on other Series.*

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First introduced by SCHONITZER. Now universally accepted. The hazard of the hook-shaped protruding handle is a thing of the past. Appearance of the whole car has been enhanced.

HOLD-OPEN-TYPE DOOR CHECK

First introduced by SCHONITZER. The automatic door holder is now a must. No longer does the door swing closed to catch one's foot or tear one's stocking.

SELF-COMPENSATING DOOR SUPPORT

First introduced by SCHONITZER. Utilizes the door as a structural member. Prevents fore-and-aft bumping of pillars on convertible bodies.

180° DOOR CHECK

First introduced by SCHONITZER. Used universally on the rear doors of panel delivery bodies. Provides 90° door opening for door to door deliveries and 180° opening for dock loading.

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SCHONITZER ENGINEERING COMPANY • 1011 POWER AVENUE • CLEVELAND 14, OHIO

HATS OFF TO THE S.A.E.

Guide Lamp Division Salutes

Your 50th Anniversary

It's a pleasure to express congratulations—on the great automotive advances of the past half century—and on the SAE spirit that will lead to the automobile of the future.

At Guide we are working in the same direction as you are . . . striving to create and improve products that add to driving comfort, convenience and safety.

A good example is the Autronic-Eye that puts headlight control in electronic hands. This General Motors engineering "first" is now offered by Cadillac and Oldsmobile.
We suggest you try it soon.

AUTOMATICALLY
AT NIGHT

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GENERAL MOTORS

GUIDE LAMP DIVISION
General Motors Corporation
Anderson, Indiana

AUTRONIC-EYE®

AUTOMATIC HEADLIGHT CONTROL

HAPPY ARE WE . . .

to be the printers of
the SAE Journal and
to serve the Society
and you, the readers.

■

Hearty congratulations
to all of you on 50 years
of splendid progress.

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Payload....75 Tons

World's largest truck uses MIEHLE-DEXTER SUPERCHARGERS

Dumping 75 tons of sand . . . or hauling copper ore up 18% grades from pit to crusher—that's the every-day job of these giant M-D supercharged trucks used by an Arizona open-pit copper mine.

...moves more material faster at lower cost!

It takes *supercharged* power to haul a load like this! When Buda Diesels were selected to power the world's biggest truck, they made *sure* of *plenty of power* with Miehle-Dexter Superchargers. Buda's experience is typical. They find that simply adding an M-D Supercharger to their engines *boosts horsepower as much as 50% or more!* What's more, weight per horsepower is decreased. Little wonder that Miehle-Dexter Superchargers are found on so many of the country's leading Diesel engines.

You, too, can keep pace with the race for more horsepower by using M-D superchargers on your engines. The investment is usually far less than required by other methods. Write for bulletin.

Only MIEHLE-DEXTER gives you all these features!

Internal construction uses patented rubber end plate seals. Eliminates metal contact, assures longer life, achieves fuel savings.

Special wear strips on rotors eliminate metal-to-metal contact, assure longer wear.

Lightweight aluminum rotors and housing boost power without adding weight.

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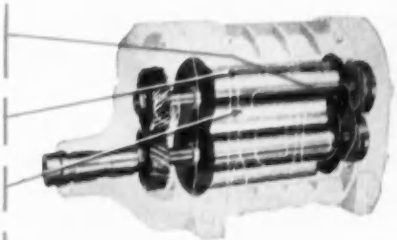

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MIEHLE-DEXTER SUPERCHARGER

DIVISION OF THE DEXTER FOLDER COMPANY

102 Fourth Street • Rocine, Wisconsin

Trust M-D Superchargers for internal combustion engines . . . use them for blower and air compressor operations, too.

Already people are saying it's the

smartest of the smart cars

It's hard to remember when a new car has caused so much comment. But it's easy to see why. Barely five feet high, here's the longest, lowest, widest, most glamorous De Soto ever built. In any one of 55 color combinations it has an eye-catching verve and beauty as modern as tomorrow. All the power you can use and every automatic feature you could want—Powerflite Transmission, Full-Time Power Steering, Feather-Touch Power Brakes, Four-Way-Power Front Seat and Air Conditioning.*

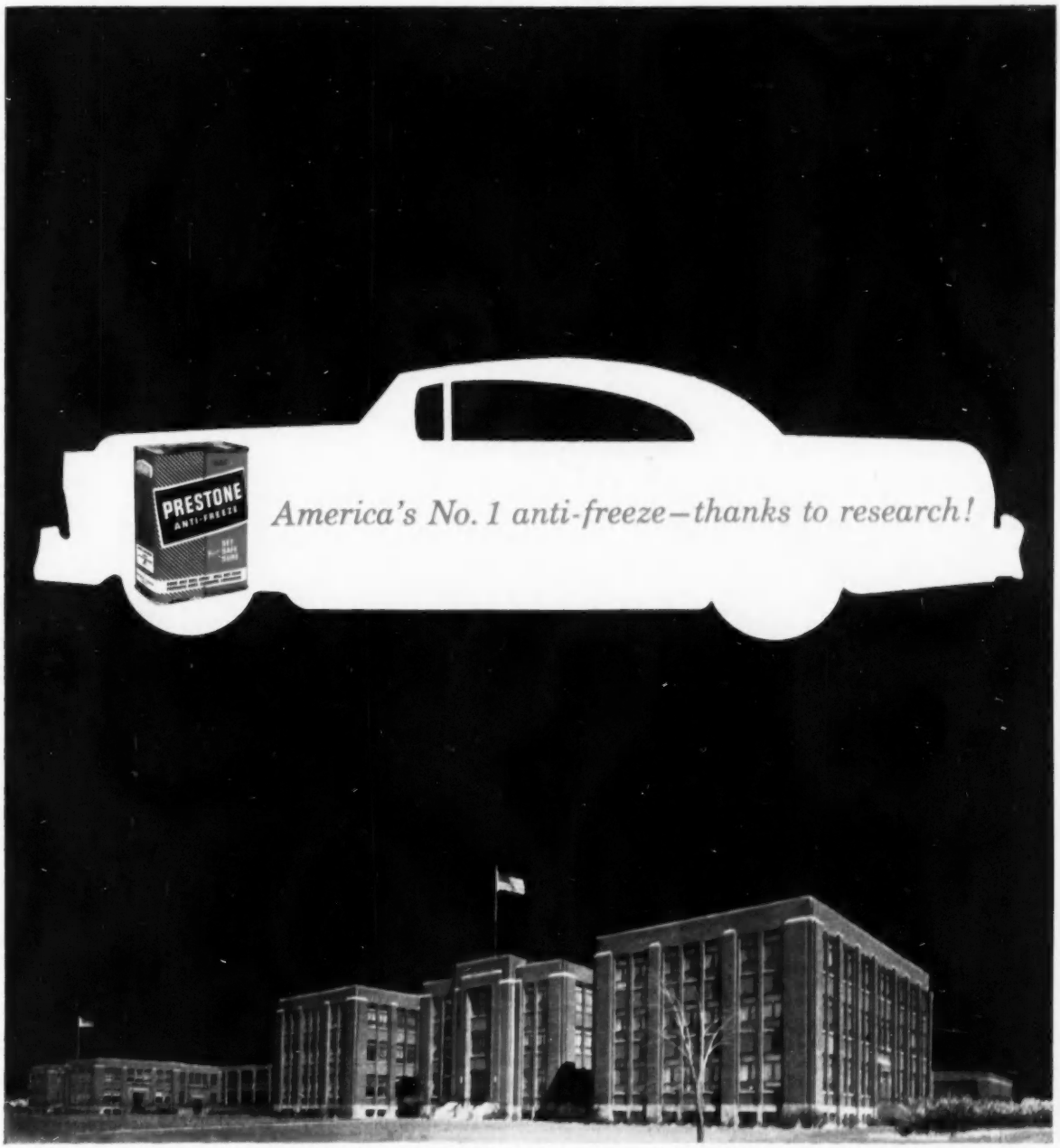
See your De Soto dealer and take a turn at the wheel of "the smartest of the smart cars." De Soto Division, Chrysler Corporation.

*Optional equipment.

TWO MIGHTY V-8's. The famous Firedome increased to 185 hp. at a new low price. Shown here is the fabulous Firelite, a brand-new 200 hp. series.

the NEW DE SOTO with the Forward Look

DE SOTO-PLYMOUTH dealers present GROUCHO MARX in "YOU BET YOUR LIFE" on NBC Radio and TV



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The terms "Prestone" and "Eveready" are registered trade-marks of Union Carbide and Carbon Corporation

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WHY NOT

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—reduce your time and costs?

WHY NOT Reinforced Vibrin for...

...complete door liners?

...rigid convertible tops?

...station wagon trim?

...seat back panels?

...hood and trunk sections?

...grille work for trucks?

Complete door liners of reinforced Vibrin could easily be formed to any contour, and even include the arm rest in one integral design. They'd be practically mar-proof—need no painting or upholstery. And they would always be pleasant to the touch, too.

Tops of reinforced Vibrin would allow almost any degree of translucency desired. They'd provide pleasant, uniformly lit interiors *without uncomfortable heat*. And *without sun glare*. They could be permanent—easily mounted or removed—or even self-storing.

Station wagon trim of reinforced Vibrin offers the beauty and distinction of wood-like grains—without fear of rot—with never a need for waxing or other protection. It's easily formed to stylish contours—and might well serve as protection for the vehicle's sides.

Seat back panels of Vibrin would need no upholstering—give all the protection desired, with beauty too. There'd be no scuffing—footmarks wipe clean with a cloth.

Hood sections of reinforced Vibrin would make hinging and counter-balancing easier. The inherent acoustical properties would deaden engine noise. And complex fairings for air intakes would pose no problem at all.

Why not reinforced Vibrin for truck fenders, cab-over-engines? Why not reinforced Vibrin grille work? Why not window trim, instrument panels, seat bases...?

Why not reinforced Vibrin for the *many* applications where its strength, light weight, beauty, and formability can not only improve your product and add to its saleability, but reduce your costs at the same time!

For more reasons why, write for our free booklets on the molding, use, and many advantages of reinforced Vibrin polyester.

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Division of United States Rubber Company

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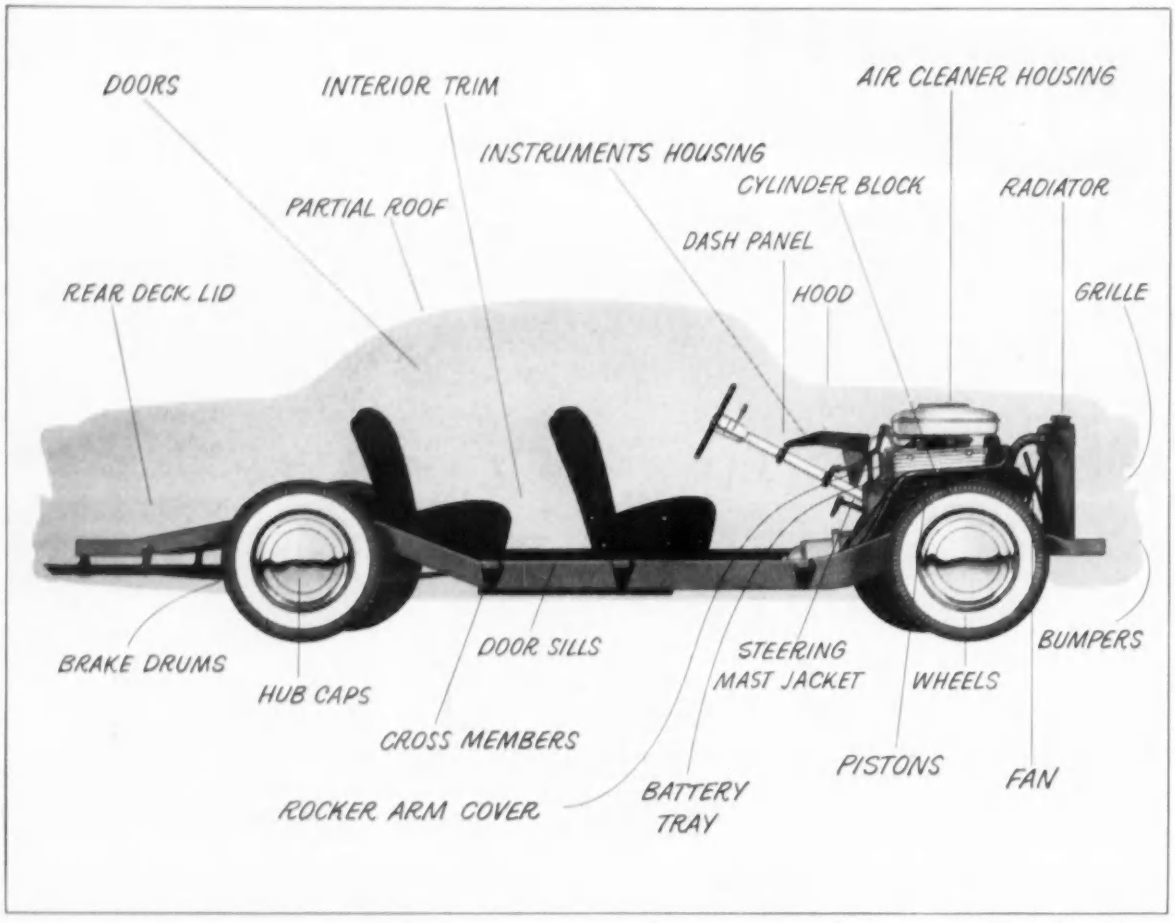


PREDICTION: ALL THESE PARTS WILL BE MADE OF ALUMINUM!

We believe that, in the near future, the use of aluminum for the 22 parts shown here will become as accepted by automotive engineers as the aluminum piston is today. In fact, we believe it's quite possible that eventually hundreds of parts will be made of aluminum.

We base this prediction on three factors.

Availability—Aluminum is now in abundant supply due to the vast expansion of the aluminum industry. You can plan to use aluminum with the assurance of continuing, dependable supply in any quantity or form you require.

Better parts—These parts will give better performance when made of aluminum because aluminum offers a *combination of advantages* no other material can match. For example, lightness, corrosion resistance, ability to deep draw on such items as battery trays mean a better product and faster, economical production.

Aluminum's lightness alone contributes to faster pickup and climb, more miles per gallon, and can lower the center of gravity. In addition, aluminum offers other advantages such as strength, heat conductivity, light and heat reflectivity.

Fabricating economy—Aluminum's workability makes it easy to fabricate, often at far less cost than other materials. It can be stretched, rolled, cast, drawn, forged, spun, stamped, extruded, and machined to make a wide variety of parts economically. And aluminum gives you a big price savings over other non-ferrous metals, because its light weight gives you up to three times more metal per pound.

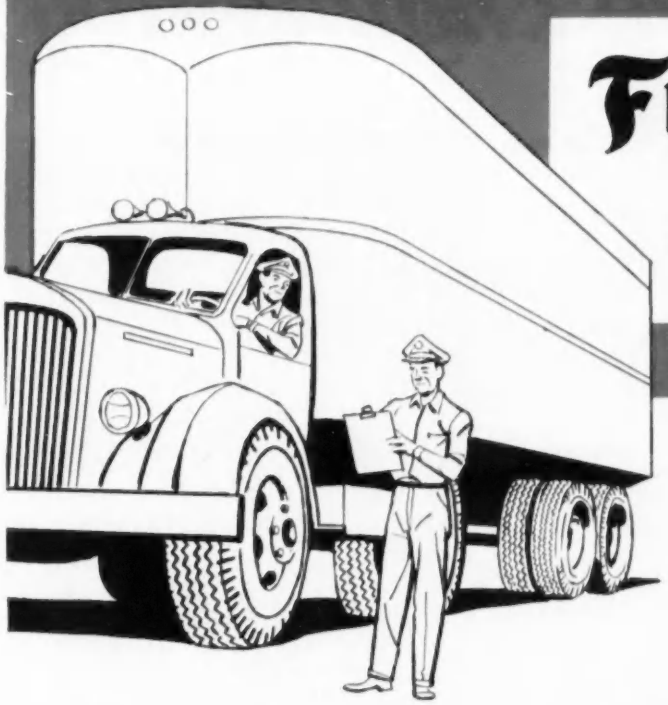
Next time you are designing a part, stop and think—can it be better made with aluminum?

As America's fastest growing producer of aluminum, we believe we are ideally equipped to work with you. For complete information, contact any Kaiser Aluminum sales office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office,* Palmolive Bldg., Chicago 11, Ill.; *Executive Office,* Kaiser Bldg., Oakland 12, California.

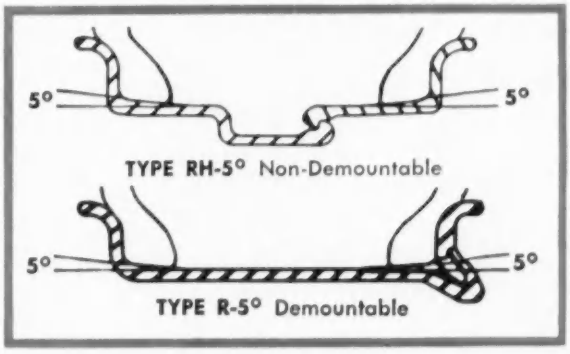
Kaiser Aluminum

setting the pace—in growth, quality and service

Fleet Operators and Drivers are Sold on Firestone Advanced TRUCK-BUS RIMS and here's why



- Greater Tire Mileage
- Lower Tire Costs
- Better Road Stability



Trucks equipped with Firestone Advanced Rims pay dividends in lower tire costs on every operating mile. No wonder more and more operators are specifying them when they order new trucking equipment. Firestone Advanced Rims are available in all sizes in both demountable and non-demountable types. For complete information write to Firestone Steel Products Company, Akron, Ohio.

Both RH-5° and R-5° Firestone Advanced Rims provide full-width 5° tapered support under both tire beads. This solid support prevents shifting or wobbling of the tire on the rim, stops bead chafing and avoids excess body strains. The tire body stays strong and serviceable much longer, resulting in greater tire mileage and more retreads than ever before.

Enjoy the Voice of Firestone on Radio or Television every Monday evening over ABC.

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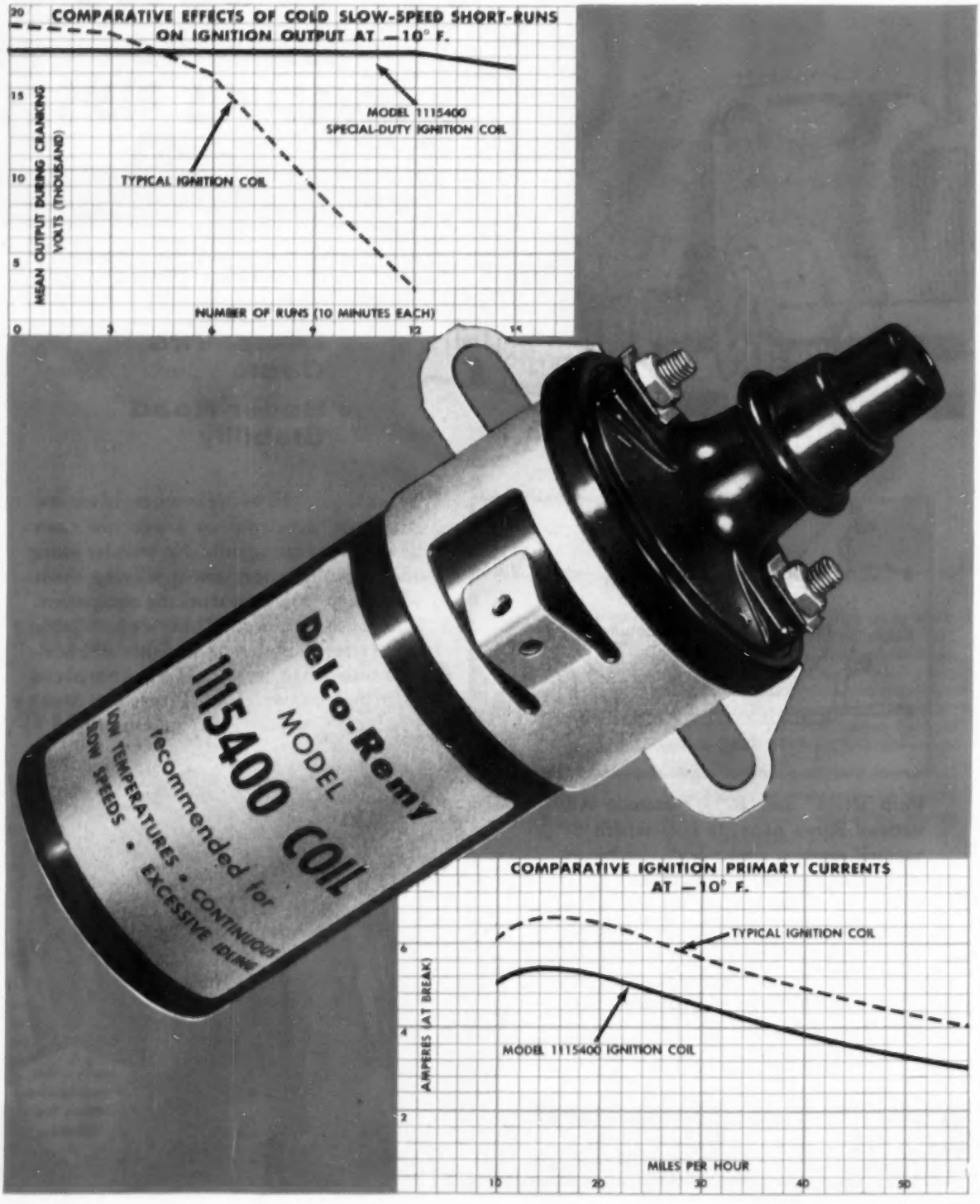
FIRESTONE STEEL PRODUCTS CO.
AKRON, OHIO

Progressive Engineering


COMPARATIVE EFFECTS OF COLD SLOW-SPEED SHORT-RUNS ON IGNITION OUTPUT AT —10° F.
MEAN OUTPUT DURING CRANKING VOLTS (THOUSAND)
NUMBER OF RUNS (10 MINUTES EACH)
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AMPERES (AT BREAK)
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Makes the Difference

HERE'S HOW DELCO-REMY ENGINEERS SOLVED WINTER STARTING PROBLEMS RESULTING FROM BURNED DISTRIBUTOR CONTACT POINTS IN 6-VOLT ELECTRICAL SYSTEMS.

Severe oxidation or "bluing" of ignition contact points is a troublesome condition in 6-volt automotive electrical systems, often resulting from repeated cold, short-run driving at low speeds in sub-zero temperatures. The cause of this condition—excessive flow of primary current—has been overcome by Delco-Remy engineers through the development of a special-duty ignition coil.

The new Delco-Remy-designed special-duty ignition coil, Model 1115400, solves this problem by controlling the flow of primary current so that the points continue to operate with warm-weather efficiency even in very cold weather. This insures easier starting, better ignition, and longer contact point life.

The Model 1115400 ignition coil also keeps contact points working more efficiently at every temperature in applications such as taxis, delivery trucks, and other vehicles, since the lower primary current minimizes the effect of low speed operation and above-average engine idling time.

This new special-purpose coil is still another example of Delco-Remy leadership in the field of automotive electrical design. When the need arises for even more specialized equipment, Delco-Remy will be ready to engineer the answer.

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Delco-Remy
ThunderVolt
ELECTRICAL SYSTEMS

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

PACKARD

welcomes a golden era

On this, the 50th anniversary of the Society of Automotive Engineers, the Packard Division of Studebaker-Packard Corporation congratulates the entire SAE membership on its combined achievements.

Packard is sure this golden anniversary is only the beginning . . . truly the start of a "golden age" of automotive transportation.

Automotive engineering has made giant strides since the inception of the SAE, and it is our sincere hope that the next fifty years will be as inspiring and fruitful as the past five decades.

PACKARD DIVISION
Studebaker-Packard Corporation

The Case of the Costly Casting

PROBLEM:

A manufacturer recently found the cost of machining a certain cast iron part had become prohibitive. How could costs be reduced?

SOLUTION:

Investigation showed aluminum permanent mold castings of the same shape would reduce machining time about 10%. But Bohn engineers went several steps further. Working closely with the manufacturer, they re-engineered the job and re-designed the cast shape. This eliminated five machining operations.

RESULT:

Machining time was reduced 80%.

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Tomorrow's oil seal here today in Victor Silicones

Type K-6 Dual Lip Silicone Pinion Seal with Flange

Patent 2172325—Sept. 5, 1939
Patent 2233902—Mar. 4, 1941

Superior bonding of Victor silicones to metal channel permits a strong, one-piece, leakproof construction. Internal lip retains lubricant; external lip excludes foreign matter. Valley in between the sealing lips is pre-lubricated for minimum friction. Cartridge-type flange allows ready removal of seal from housing without damage.

Here's the oil seal that makes a complete break with yesterday's sealing elements of tired leather, leather with additives . . . even steps out far ahead of synthetic rubber.

Here, Victor-developed silicones start a new era of automotive sealing progress, in highly engineered designs for tomorrow's tougher, more exacting needs. Tested as original equipment since 1953, Victor Silicone Seals were the first of their kind to merit approval by the auto industry.

Advantages of silicones, found in Victor's earliest pioneering of these compounds, have been developed to the finest degree. Their suitability for high temperatures beyond 300 deg. F., and for high peripheral speeds, measurably exceeds that of conventional materials. They work well with the new lubricants. Throughout life, the element remains flexible and operative, does not harden or get brittle.

These premium seals can now be specified in the competitive market. Victor's skill in manufacturing—as in development—has led the way to large-quantity production at prices consistent with performance values. Your inquiry is invited.

VICTOR Silicone Oil Seals

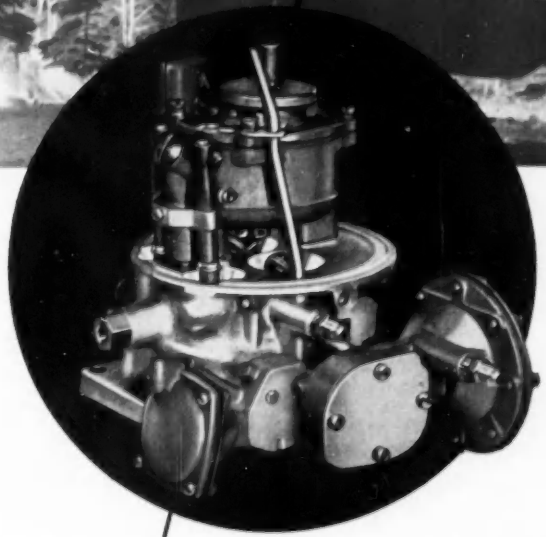
Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill.

Sealing Products Exclusively • Oil Seals • Gaskets • Packings

INTERNATIONAL *Pioneers the move* TO 4-BARREL CARBURETION!

HOLLEY CHOSEN FOR POWERFUL NEW 501 ENGINE SERIES

International's most powerful new engine—the Royal Red Diamond 501 valve-in-head—is installed in the new 220 truck series. This amazing new engine delivers 201 horsepower and 430 pound-feet of torque. *It is the first production truck engine to be equipped with a 4-barrel carburetor.*



This Holley-developed 4-barrel carburetor increases both engine output and power range. It is the first 4-barrel carburetor with a built-in governor; first with vacuum controlled secondary barrels.

The secondary barrels remain closed at low engine speeds, allowing the engine to maintain satisfactory velocities and distribution. Then, as engine speed increases to a point where additional breathing capacity is needed, the vacuum controlled secondary barrels open automatically.

Working closely with International engineers, Holley designed and developed this advanced carburetor-governor combination. It is original equipment on all tractors and trucks in International's new 220 series.

If *you're* wondering how to do a job of fuel metering better and more efficiently, call Holley's Carburetor Engineers. Let them listen, test, recommend and design.

For Holley carburetor parts and service for International trucks, see your local International Harvester outlet.

HOLLEY *Carburetor Co.*

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Working with Automotive Engineers to Increase Standards of Performance and Economy for More than Half a Century.

HI-EFF TAYLOR HYDRAULIC DYNAMOMETERS

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Widely used by manufacturers of

- TURBINES • DIESEL ENGINES
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Many Other Applications
It will pay you to write for Bulletin 761

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Manufacturers of HI-EEF Hydraulic Dynamometers—Static Balancing Machines—Sensitive Drilling Machines

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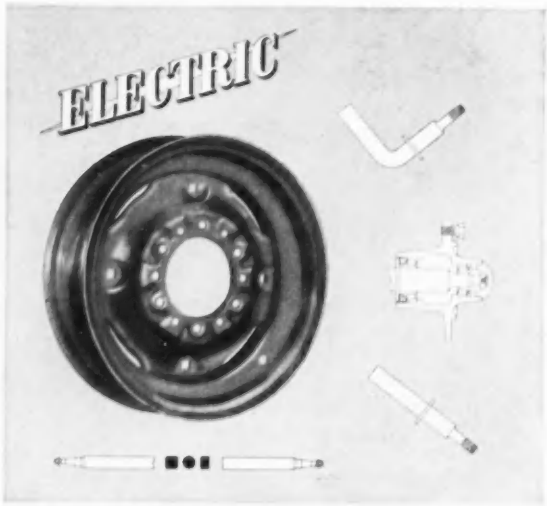

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new V-12

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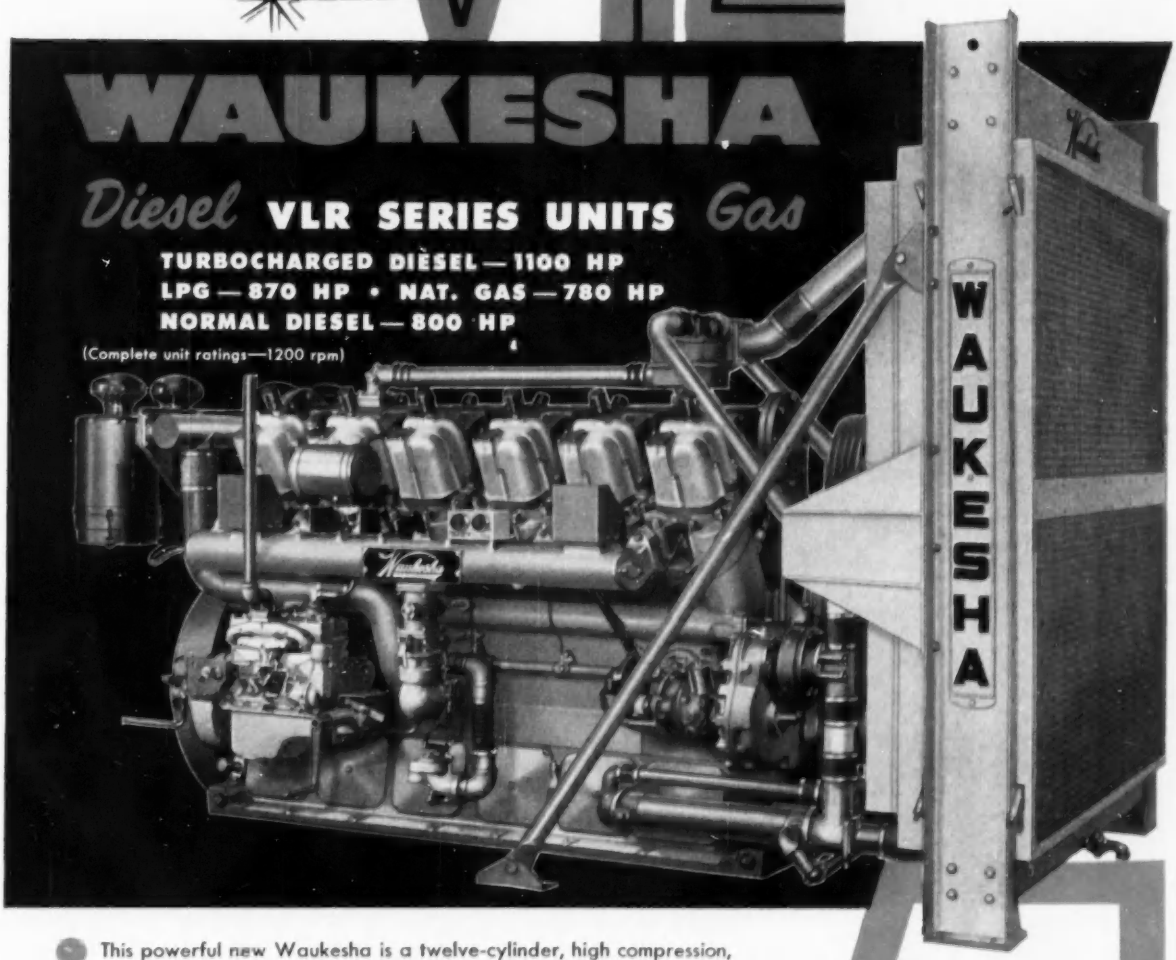
Diesel VLR SERIES UNITS *Gas*

TURBOCHARGED DIESEL — 1100 HP
LPG — 870 HP • NAT. GAS — 780 HP
NORMAL DIESEL — 800 HP

(Complete unit ratings—1200 rpm)



This powerful new Waukesha is a twelve-cylinder, high compression, overhead valve, 60-degree vee, four-cycle engine of 8½-inch bore and stroke, and 5788 cubic inch displacement. Connecting rods are side by side type; opposing pistons operating from a single wide-area crankpin. Bare engine ratings at 1200 rpm are: Turbocharged Diesel, 1135 hp; Normal Diesel, 830 hp; Butane-Propane, 900 hp; Natural Gas, 810 hp. Response to throttle and load requirements is quick and smooth, with a fast surge of reserve power for emergency and overload demands. Tremendous in power, remarkably rugged, the V-12 is designed for simplicity and reliability. Major parts are interchangeable between right and left cylinder banks. Main and rod bearings are easily accessible. Strength, precision and balance are built into all elements of the power train, from pistons to flywheel. Supporting members are designed for extreme rigidity and perfect alignment of moving parts. Send for Bulletin 1656.

WAUKESHA MOTOR COMPANY

WAUKESHA, WIS.

NEW YORK • TULSA
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Grumman

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The U. S. Navy tracks aircraft on a transparent board as radar reports their positions. Plot the most famous Navy and Marine fighter planes as reported by history, and Grumman aircraft fill the board.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
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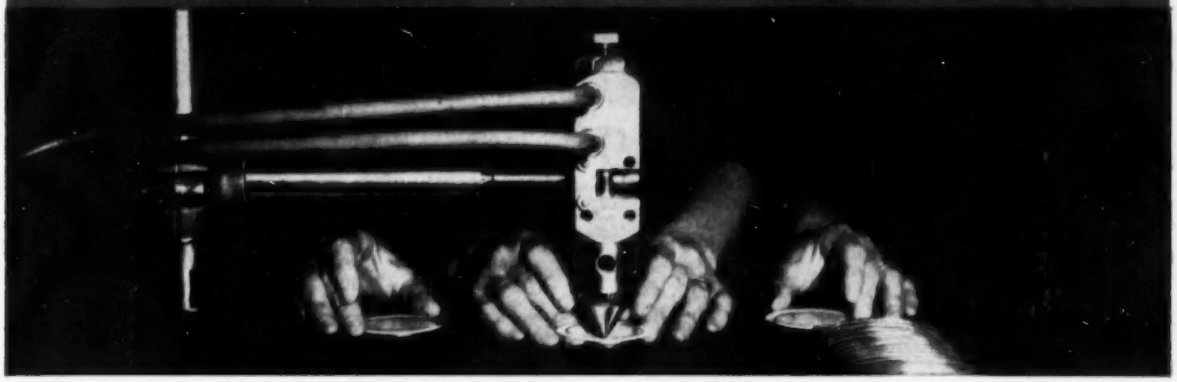
DESIGNERS AND BUILDERS ALSO OF THE ALBATROSS TRIPHIBIAN, S2F SUB-KILLER, METAL BOATS, AND AEROBILT TRUCK BODIES

THESE PHOTOS SHOW HOW YOU SAVE MOTIONS and MATERIAL

with the DAREX "Flowed-in" Gasket Process

THE OLD-FASHIONED WAY. See the number of motions required to apply a single gasket to a single part by hand. All these hand motions are time and cost-consuming.

THE "FLOWED-IN" WAY. With a DAREX semi-automatic machine, there are only two hand motions. Operator feeds with one hand, clears with the other. Compare the easy, efficient motions of this operator's hands with the many operations necessary to apply a gasket manually.



WHEREVER "Flowed-in" gaskets are used, they cut deeply into the cost of hand assembly. If you've ever added up the excessive time, motions and money required in hand assembly of gaskets to your parts, you'll appreciate the "Flowed-in" principle as the outstanding gasket development of the decade.

The "Flowed-in" Process is amazingly simple. A fluid flows onto a spinning surface. As the surface revolves, a uniform circular track of "Flowed-in" gasket material is deposited on the part. Baking or drying transforms the fluid into a rubbery gasket that won't fall off the part.

The DAREX Process leads to savings: In labor — by eliminating hand assembly. In materials — by eliminating waste and improving quality. Or, more probably, in both!

DEWEY and ALMY
Chemical Company
DIVISION OF W. R. GRACE & CO.
Cambridge 40, Massachusetts

FULLY PROVEN — The DAREX Flowed-in Gasket Process is more than a sealing compound . . . more than a machine . . . more than an engineering service. When you switch to Flowed-in Gaskets you get:

Gaskets with built-in resistance properties — Over 800 gasketing formulations have been tested for their effectiveness against high and low temperatures, weather, gases, solvents, moisture, vibration, hydraulic fluids, pressure . . . other problem conditions.

Machines — To apply the compound, Dewey and Almy designs and builds machines based on more than 30 years' field experience.

Service — Every machine is adjusted precisely to your specifications. Dewey and Almy engineers install the machines and train your operators to full efficiency.

Discover what DAREX "Flowed-in" GASKETS can do for you!

MAIL THE COUPON TODAY!

DEWEY AND ALMY CHEMICAL COMPANY
Division of W. R. Grace & Co.
Cambridge 40, Mass.

Please send me the new DAREX Flowed-in GASKET Brochure.

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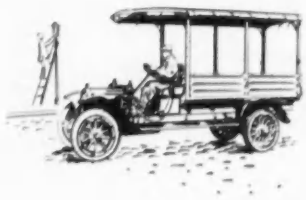
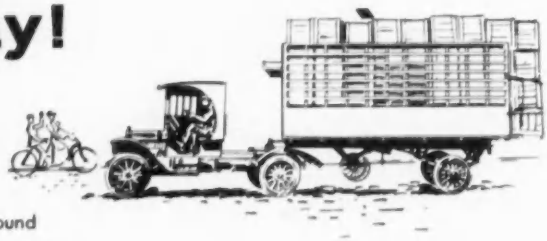


We've come a Long White Way!



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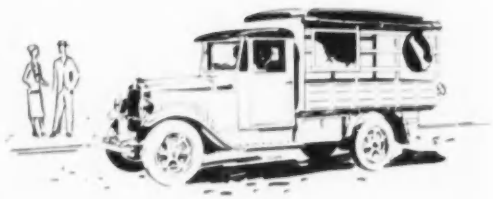

White builds the greatest money-savers, money-earners on the road today . . . more reason than ever before to look to White for truck leadership . . . in action.

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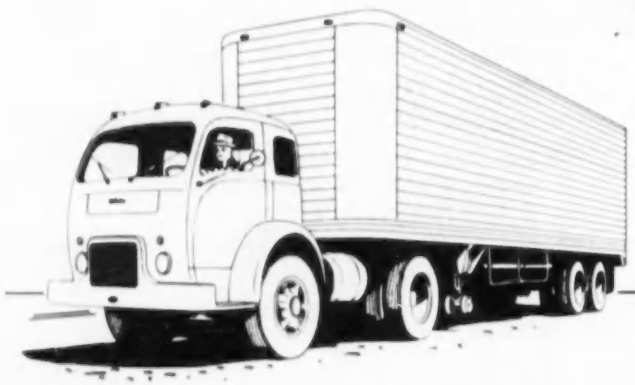

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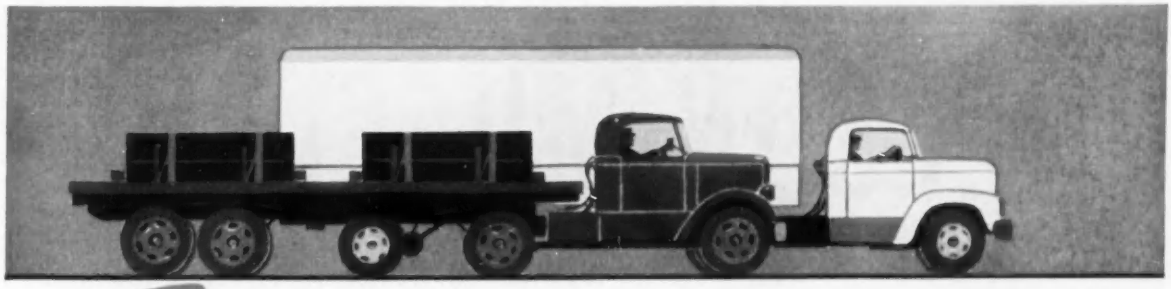

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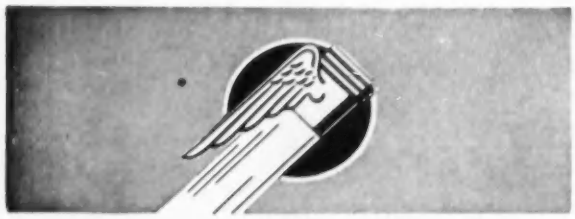

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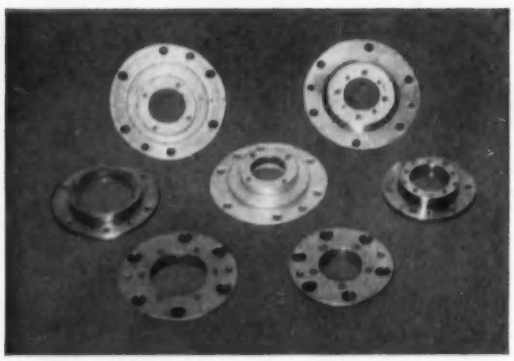

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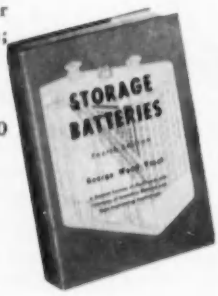

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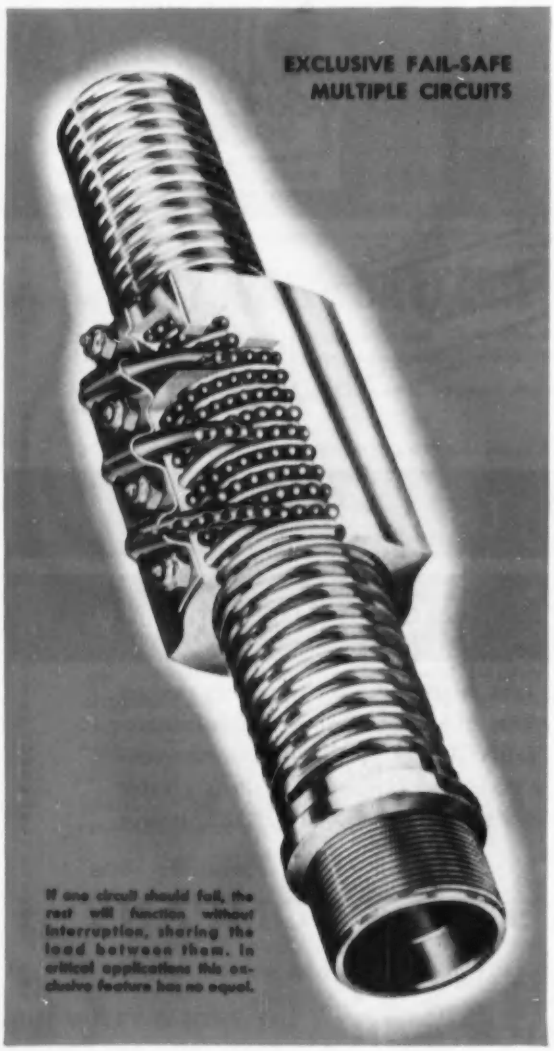
WEIGHT, POWER OR

The Safety ball/bearing Screw can help you solve them!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Today a remarkably efficient actuating system, old in principle but relatively new to aviation, is being rapidly adopted by aircraft engineers as the successful solution to many actuation and control problems.

Pioneered by Saginaw to reduce automobile steering effort, the *Safety ball bearing Screw* operates at 90% to 95% efficiency—about three times that of the conventional Acme screw. Already it has been used with outstanding success by most leading aircraft builders.

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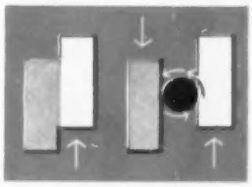
Every *Safety b/b Screw* is individually engineered for its particular application, with the wealth of know-how that only Saginaw, the pioneer, can offer. Our engineers are ready and eager to help solve your actuator problems *now*.

Safety ball bearing Screw

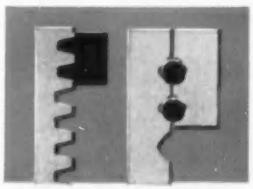
TEMPERATURE PROBLEMS?

WHAT IT IS AND HOW IT WORKS:

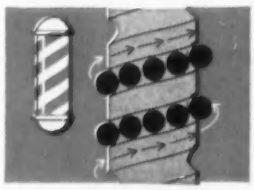
The Balls Go Round and Round and They Come Back Here!



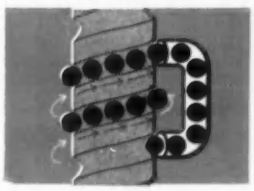
Let's start at the very beginning—with the familiar principle that there's far less friction in *rolling* than in *sliding*. The coefficient of sliding friction ranges from approximately .001 to .4—while the coefficient of rolling friction ranges from about .0005 to .003.



By applying this principle, the *Safety ball bearing Screw* radically increases the efficiency of rotary-to-linear (or linear-to-rotary) motion. Instead of *sliding* against each other, the surfaces of the screw and mating nut glide on rolling balls.

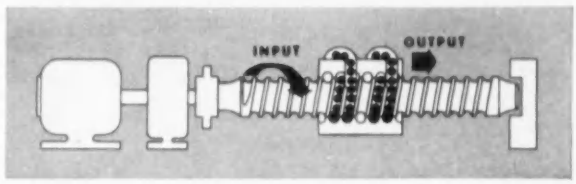


Like the stripes on a revolving barber pole, the balls travel toward the end of the nut through the spiral "tunnel" formed by the concave threads in both the nut and the screw.



At the end of their trip, one or more tubular ball guides constantly swallow the balls, lead them diagonally across the outside of the nut and back to their starting point. This forms a closed circuit through which the balls continually recirculate when the nut and screw are rotated relative to each other.

HOW IT CAN HELP SOLVE YOUR AIRCRAFT ACTUATION PROBLEMS



Compared with the conventional Acme screw's efficiency of less than 25%, the efficiency of the *Safety b/b Screw* ranges from *90% to 95%!* This makes it by far the most efficient known mechanism for translating rotary-to-linear motion, or vice versa. Combined with an electrical, hydraulic or pneumatic power source, the *Safety b/b Screw* forms an actuator with tremendous advantages for the aircraft engineer. For example, it can enable you to:

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SAVE POWER—by requiring only 1/3 as much torque as a conventional Acme screw for the same amount of lineal output, the *Safety b/b Screw* permits the use of much smaller motors with far less load on the electrical system.

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ASSURE POSITIVE POSITIONING—unlike some other types of actuators, the *Safety b/b Screw* permits precision control within thousandths of an inch, plus perfect synchronization of two or more movements.

INCREASE DEPENDABILITY—the *Safety b/b Screw* decreases combat vulnerability, offers the added security of *exclusive multiple circuits*, and reduces maintenance requirements because its "Gothic arch"-shaped races greatly decrease dirt sensitivity.

REDUCE PART AND INSTALLATION COSTS—in addition to all these design, operating and maintenance advantages, the *Safety b/b Screw* also cuts costs by permitting the use of smaller motors, decreasing power and auxiliary equipment requirements.

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Shown at right is an assembled unit of the Dualoc Non-Equalizing Differential complete with ring gear.

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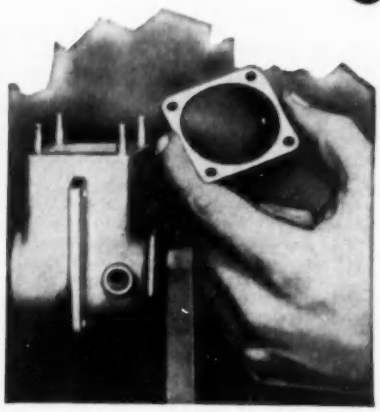

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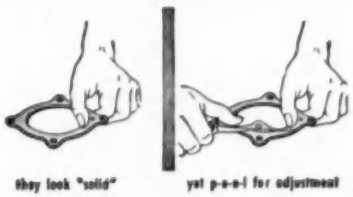

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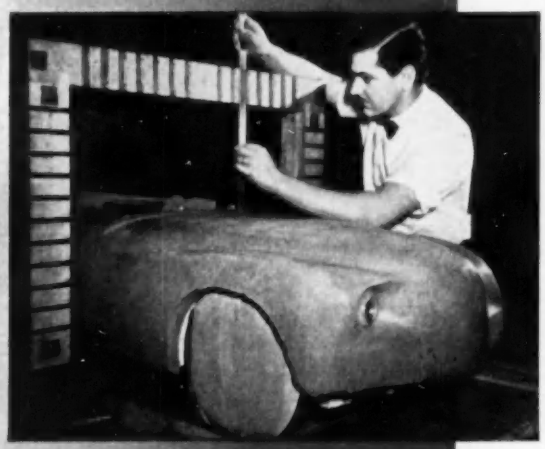

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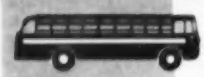

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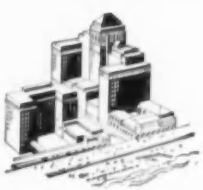

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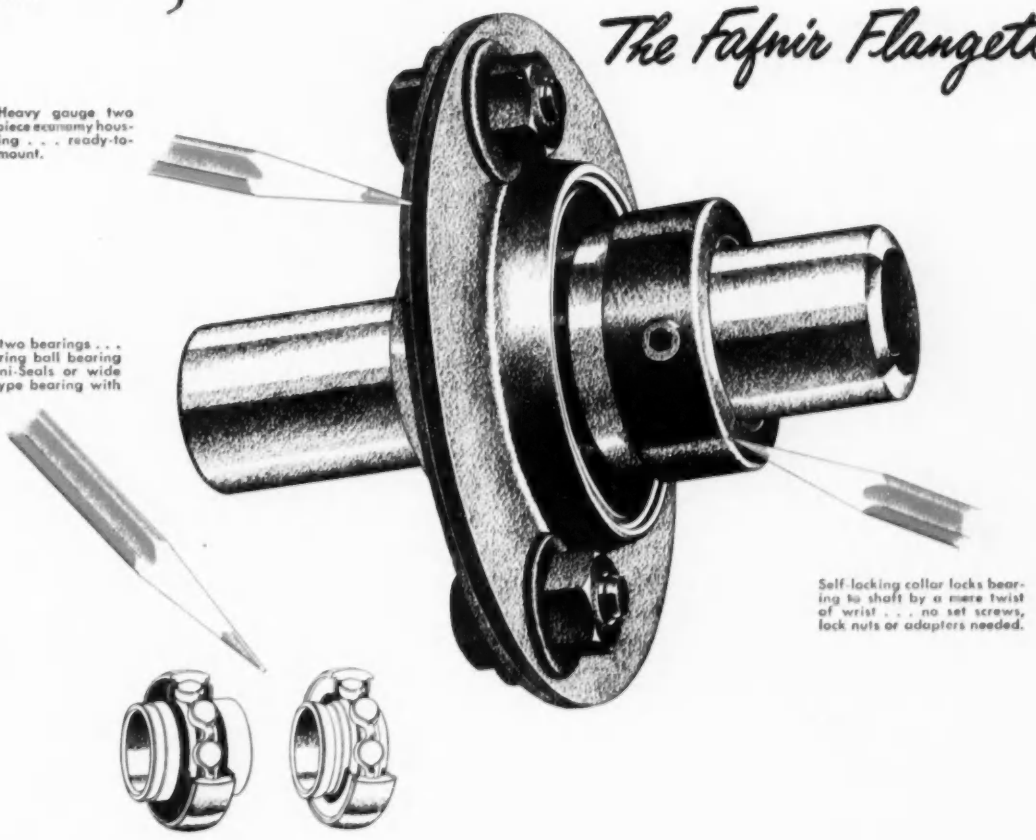
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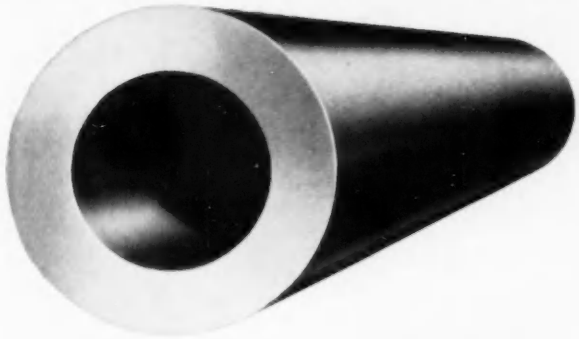
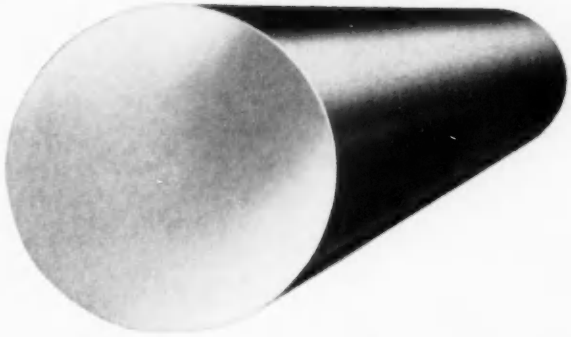


instead of bar stock



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